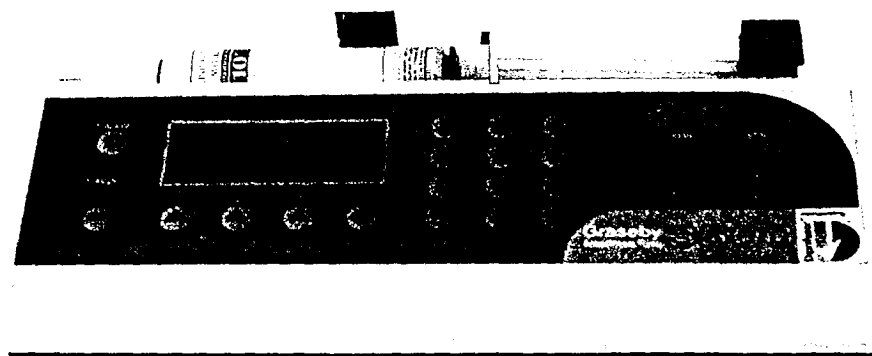


Graseby 3500

Anaesthesia Syringe Pump

TECHNICAL SERVICE MANUAL



GRASEBY

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ISSUE RECORD

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General

This *Technical Service Manual* (TSM) together with the *Instruction Manual* for the 3500, contains the information that is required in order to carry out the following actions to the pump:

- Operation.
- Maintenance.
- Repair.

The TSM is primarily intended to be read and used by suitably qualified personnel.

Different versions of pump

The 3500 infusion pump may be manufactured in two separate and distinct versions, as follows...

- to administer a 'Manually Controlled Infusion (MCI) *only*' using various brands of syringe.
- to administer a 'MCI *plus* a Target Controlled Infusion' (TCI). This version of the pump uses the Zeneca Diprifusor™ PFS, and various other brands of syringe.

Each version is easily identified. The 'MCI *plus* TCI' pump has a front panel that shows the Diprifusor brand name and the 'Diprivan' logo as shown below:



The 'MCI *only*' pump does **not** have this front panel logo.

The 'MCI *only*' pump can easily be converted to a 'MCI *plus* TCI' pump at the Graseby Medical Service Centre. During this conversion the Diprifusor front panel logo will be added to the pump.

This service manual covers both versions of the pump. The reader is given the relevant instructions for each version, and will be able to determine how both versions function.

Warnings and caution

Warnings and cautions are given throughout this manual. The *general* warnings and caution are given below.

WARNINGS

Only qualified personnel should maintain and repair the 3500.

The 3500 must be set to operate with the brand of syringe that is going to be used. Using a different brand to that selected could lead to the incorrect amount of drug being administered.

The 3500 must be disconnected from the AC power supply before the pump's case is unscrewed and opened.

CAUTION

The Printed Circuit Boards (PCB) contained in the 3500 are electrostatically sensitive. Use an earthing strap when handling a PCB to avoid electrostatic damage to the components situated on the PCB. Ensure that replacement PCB are stored in anti-static containers.

Abbreviations and trademark

Abbreviations used The following list shows the abbreviations that have been used at various places throughout this Manual.

<u>Abbreviation</u>	<u>Full meaning</u>
A	Ampere
A to D	Analogue to Digital
AC	Alternating Current
C	Capacitor
°C	Degrees Celsius
CPU	Central Processing Unit
cm	Centimetre
csk	Counter-sunk
CRC	Cyclic Redundancy Check
DC	Direct Current
Fig.	Figure
g	Gram
Hg	Mercury
Hz	Hertz
IC	Integrated Circuit
kg	Kilogram
KVO	Keep Vein Open
LED	Light Emitting Diode
MCI	Manually Controlled Infusion
mA	Milliampere
mg	Milligram
ml	Millilitre
mm	Millimetre
PCA	Patient Controlled Analgesia
PCB	Printed Circuit Board
PL	Plug
PWM	Pulse Width Modulation
PFS	Prefilled syringe
R	Resistor
R.F.	Radio Frequency
RAM	Random Access Memory
ROM	Read Only Memory
TCI	Target Controlled Infusion
TPC	Target Plasma Concentration
V	Volts

**Zeneca
Trademark** Diprifusor™ (Target Controlled Infusion...TCI, Software/
Subsystem/System) and the stylized D with arrow logo are
trademarks, the property of Zeneca Limited.

The Zeneca PFS is used for the infusion of the drug
'Diprivan'(D).

CHAPTER 1

INTRODUCTION AND SPECIFICATION

Introduction

The 3500 anaesthesia syringe pumps' (Fig. 1-1 and 1-2) are based on a micro-controller design, and have been purpose developed by Graseby Medical for the administration of anaesthetics, mainly in a hospital operating theatre.

The two versions of the pump are very similar, and may be easily recognised by looking at the front panel markings. The pumps basically function as follows:

- 'MCI *only*'...
this version of the 3500 allows a Manually Controlled Infusion and/or a bolus using the normal brands of syringe. The infusion entails presetting into the pump both the required infusion rate and the dose of the drug that is going to be used.
- 'MCI *plus* TCI'...
this version of the 3500 is able to use several brands of syringe for MCI or, a Zeneca PFS for the TCI. During a TCI, the infusion rate will be controlled by the Diprifusor module in order to achieve and then maintain a desired Target Plasma Concentration (TPC).

The pump is a compact robust unit that is able to function either sitting on a table top or mounted on a pole clamp.

MCI only pump

The MCI *only* pump can be configured by a suitably qualified person to work with any one of several selected *brands* of syringe, plus, when converted, the Braun Perfusor syringe. The particular *brand* of syringe selected will be displayed.

The diameter of the syringe installed and hence its *volume*, is automatically sensed by the pump. The separate syringe *volumes* that can be sensed and will be displayed are:

5; 10; 20; 30 and 60 millilitres.

Introduction

MCI *plus* TCI pump

A tag on the Zeneca PFS ear allows positive identification of the Diprivan drug when the MCI *plus* TCI version of the pump is being used in TCI mode.

Note:

This version of the pump cannot be converted to operate with the Braun Perfusor syringe.

General information

The 3500 can be configured to:

- deliver a volume or mass unit manual controlled infusion, or
- a volume or mass unit bolus infusion.

A running total of the volume of liquid that has been infused is stored in the pump's totaliser, and will remain available for display even though the infusion may have been stopped and then restarted. The totaliser can be set to zero when required.

The pump can be operated from AC power or from internal rechargeable batteries. When functioning on fully charged batteries the pump gives more than ten hours of continual use.

The AC power can vary between 100V and 250V and 50 to 60 Hz, thus allowing the pump to be used anywhere in the world without adjustment.

A battery charging circuit within the pump keeps the batteries charged. The batteries are fully charged when the AC power has been connected to the pump for 14 hours, even though the pump itself may be switched off.

The pump carries out a self-testing routine each time it is switched on.

Numerous safety features have been built into both the software and the hardware, and the user is warned of such incidents as a power failure or an occlusion by both visible and audible alarms.

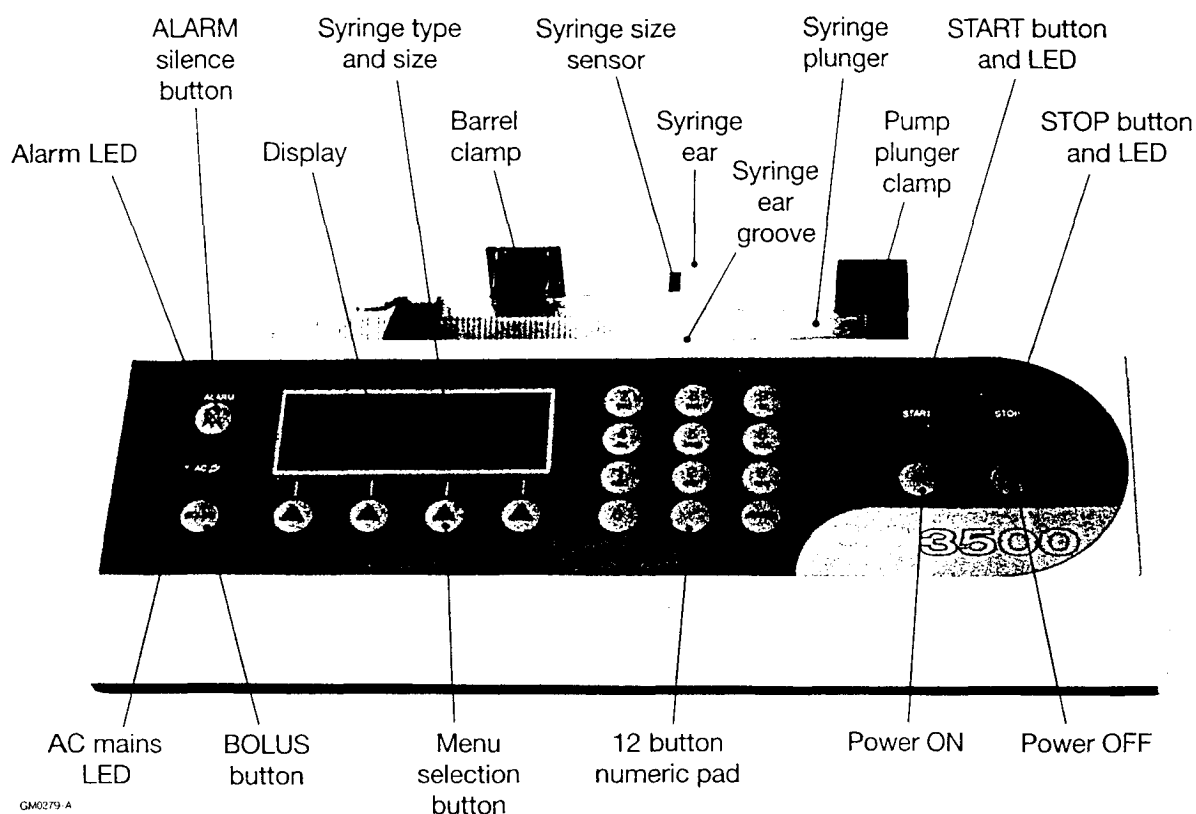


Figure 1-1 Front view of the 'MCI *only*' 3500 pump

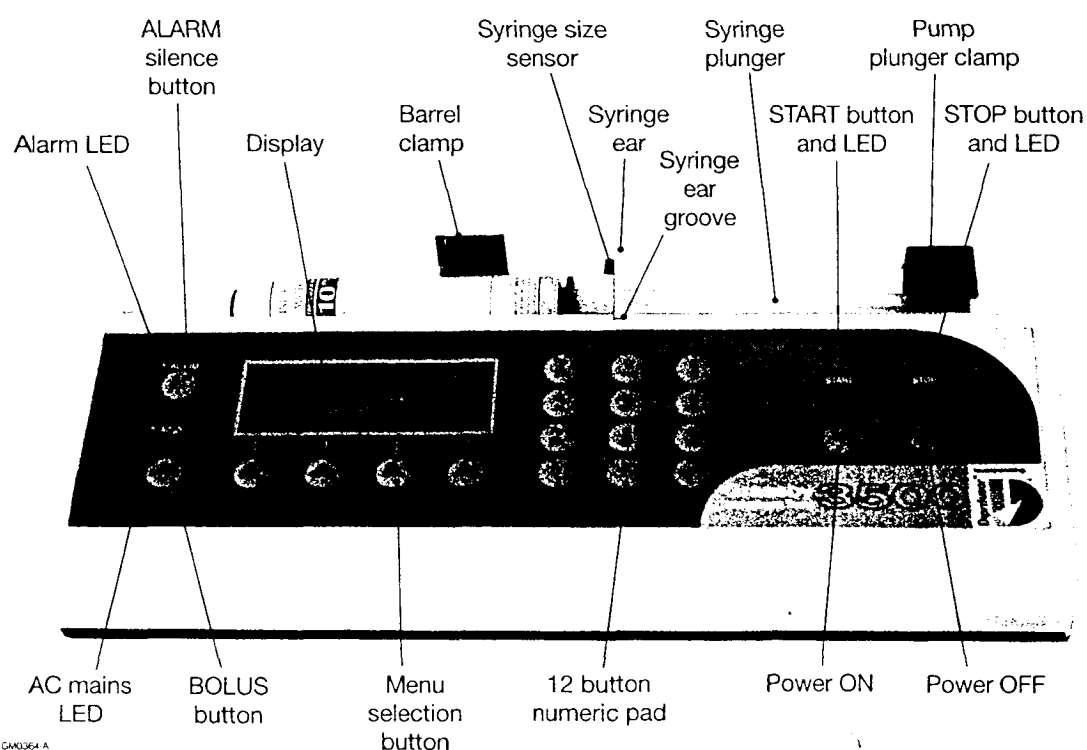


Figure 1-2 Front view of the 'MCI *plus* TCI' 3500 pump

Features

Features

The main *features* of the 3500 are as follows:

- Simple to use.
 - Ergonomic styling.
 - Easy to service.
 - AC powered or internal battery powered.
 - Advanced safety features.
 - For the MCI only version of the pump a selection from several brands of syringe can be made, also the pump may be converted to work with the Braun Perfusor 50 ml syringe.
 - For the MCI plus TCI version of the pump, a selection from several brands of syringe can be made when MODE=NORMAL. But only the Zeneca PFS can be used when MODE=TCI.
 - Automatic syringe size sensing.
 - A clear text display.
 - A comprehensive range of alarms. For example the pump gives a *Syringe Invalid* alarm; a syringe *Nearly Empty* alarm; etc.
 - Designed in consultation with users.
-

Specification

Graseby Medical pumps are subject to continual development and the 3500 may, therefore, differ slightly from the following specification:

- Dimensions: 325 mm (long) x 130 mm (high) x 90 mm (deep).
- Weight: 2.4 kg (including batteries).
- AC Supply: 100 to 250 V; 50/60 Hz. The pump's power supply uses a Primary Switching technique.
- Battery type and life: Sealed lead acid (Cyclon). More than ten hours of operation when fully charged. Operation is defined as infusing at 1200 ml/h (60 ml syringe) for no more than 10% of the time and less than 400 ml/h for the rest of the time.
- Syringe brands:

BD Plastipak	5;10; 20; 30 or 50/60 ml.
Terumo	5; 10; 20; 30/35 or 50/60 ml.
Braun Omnifix	5;10; 20; 30 or 50/60 ml.
Monoject	5; 10; 20; 30/35 or 50/60 ml.
IMS Pump-jet	30 ml (prefilled).
Injectomat	50 ml.
Zeneca PFS	50 ml.
Nipro	5; 10; 20; 30 or 50/60 ml.
JMS	5; 10; 20; 30 or 50/60 ml.
Braun Perfusor	50 ml (MCI only; conversion kit required, refer to Chapter 8).
- Flow rate:

'MCI only' ...	
Continuous;	0.1 to 400 ml/h in 0.1 ml increments.
Mass units;	mg/kg/h etc.
Bolus;	0.1 to 1200 ml/h in 0.1 ml increments.
'MCI plus TCI' ...	
	0.1 to 1200 ml/h.
- Totaliser: 0 to 999.9 ml in 0.1 ml increments.
- Adjustable occlusion pressure: 250 mm Hg to 850 mm Hg.
- Operating temperatures: 5 °C to 40 °C.
- Drive accuracy: $\pm 2\%$ when measured over a complete syringe.
- Design standards: IEC 601-1.
- Elec. safety: Class II; Type CF.
- Languages available: Selectable via the configuration mode.

Brief history of Graseby bedside syringe pumps

The first Graseby Medical bedside syringe pump was the **MS2000**. This was a basic syringe pump capable of infusions within the range of 0.1ml/hr to 99.9ml/hr. It had a totaliser, a limited infusion capability, a built in pole clamp and was designed for vertical operation. The MS2000 could be powered by an AC supply or its internal DC batteries.

The Graseby **PCAS** pump was developed from the MS2000 to satisfy the growing interest in Patient Controlled Analgesia. The Graseby PCAS was very similar to the MS2000 in both appearance and mechanical design, but utilised a different microprocessor with the capability of running the extra features required for PCA. A printer port was also incorporated.

The first member of the 3000 series syringe pumps was the **3000** itself. This was designed as a low-cost alternative to the MS2000 and satisfied the need for a horizontally mounted pump. The 3000 had no internal battery supply. The 3000 is no longer produced by Graseby Medical.

The **3100** syringe pump was developed from the 3000. It is very similar mechanically but the electronic design was superior. Dual processors were incorporated along with a vacuum fluorescent text display and internal batteries. The maximum infusion rate was increased to 199.9ml/hr and different syringe sizes could be used (automatically sensed). Extra software features such as the intelligent 'near end' alarm system were also incorporated.

The next bedside syringe pump to be developed was the **3300**. This was similar in mechanical and electronic design to the 3100 but the features were specifically for the now more mature PCA market. A lockable syringe cover was added for security against drug theft, a four line LC display was added, and internal history recording with printout was also added. With the growth in PCA knowledge in the medical community, many more software features were incorporated into the 3300 to aid PCA administration.

The **3400** was developed (again from the Graseby 3100) to satisfy the need for a high speed infusion pump for intravenous anaesthesia. Advances in micro-controller technology allowed the use of a single device to control all the pumps features. The maximum infusion rate was raised to 1200.0 ml/hr and bolusing facilities were added to the software. Later, an infusion rate calculation facility was also added to the software.

A larger liquid crystal display was used on the 3400 with the ability to display text in different sizes, and 'soft-keys' to make the user interface simpler. The range of syringe sizes which could be used was increased. Also, for more advanced applications, the 3400 could be controlled by a computer.

The **3200** was developed as a high end general purpose syringe pump. Wet-side pressure sensing, intermittent infusion capabilities, and computer interfacing were added. The wet-side occlusion pressure monitoring make the pump particularly suitable for use in intensive care baby units. A large text vacuum fluorescent display was added, and the increased syringe size range of the 3400 remained.

There are two versions of the **3500**, as detailed on page xii and shown below:

- A Manually Controlled Infusion (MCI) *only* pump.
- A MCI *plus* a Target Controlled Infusion (TCI) pump.

The 3500 was developed from the 3400, and retains all the 3400 facilities. The 'MCI *plus* TCI' pump carries out a TCI using the Diprivan drug. This version of the 3500 incorporates a Diprifusor *module* manufactured by Zeneca Pharmaceuticals. A new main circuit board and new software allows the 3500 to interface with the Diprifusor *module*.

CHAPTER 2

CONFIGURATION MODE, DIAGNOSTICS AND THRUST ADJUSTMENTS

Configuration mode

WARNING

The configuration mode must only be used by personnel who have been appropriately trained in using the 3500

Introduction

The configuration mode allows ten pump parameters to be made available, which in turn allows various settings within nine of these parameters to be set to the values required for the infusion.

The list shown below shows each parameter within the configuration mode, and each parameter is further detailed in the sections that follow:

1. Syringe brand.
2. Display language.
3. Bolus beep.
4. Preset bolus.
5. Mass units.
6. LCD contrast.
7. Baud rate.
8. TCI present (set at manufacture).
9. Mode.
10. Max rate.

(contd.)

Configuration mode

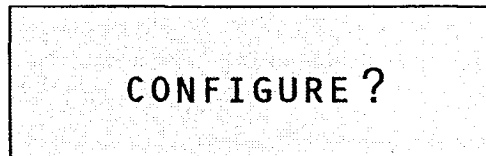
Calling up the configuration mode

With the AC power connected and switched on (or under internal battery power) press the **ON** button. The pump will carry out its self tests and will then be in its 'set up' mode.

Press the second ▲ button from right, and the **BOLUS** button simultaneously...

i.e. press ▲ ▲ ▲ and **BOLUS** simultaneously.

The display will show the following question:

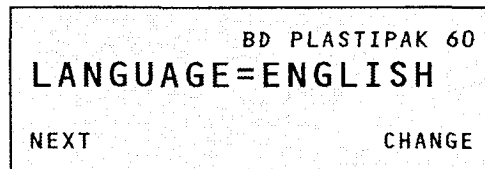


Within two seconds press the **START** button to confirm that you want to enter the configuration mode.

A display similar to the one shown below will then appear:

Note...

If the **START** button is not pressed within two seconds the pump will return to its 'set up' mode.



Changing a setting

Press the **CHANGE** options menu button repeatedly in order to scroll through the options that are available for each parameter. The displayed option will be retained when the **NEXT** or **STOP** button is pressed.

The various settings are retained in non-volatile memory

Moving to the next parameter

Press the **NEXT** menu button in order to move to the next parameter and if a new selection is required repeat the above.

Press the **STOP** button at any setting in order to exit from the configuration mode and return to the 'set up' mode.

(contd.)

Configuration parameters and settings that are available

Syringe brands	1. Choice:	BD Plastipak Terumo Braun Omnifix Monoject IMS Pump-jet 30 Injectomat Zeneca PFS Nipro JMS Braun Perfusor: MCI only pump. A conversion kit is required, see Chapter 8.
Display language	2. Selection:	The display language required is selected by scrolling to it.
Bolus beep	3. Yes or No:	Set to YES if you wish the pump to beep whilst delivering a bolus. If a bolus beep is not required then set to NO .
Preset bolus dose	4. Yes or No:	Set to YES if you require the option to use the preset bolus (i.e. dose is preset for a <i>Hands Free</i> bolus infusion). Set to NO if the preset bolus is not required (i.e. the infusion dose is controlled by the user during the <i>Hands On</i> bolus infusion).
Mass units	5. Yes or No:	If the MASS UNITS parameter is set to YES then it will be possible to preset the pump to deliver an infusion in mass units, e.g. <i>mg/k/g/h</i> etc. If the MASS UNITS is set to NO then <i>ml/h</i> will be the only selection available.

(contd.)

Configuration mode

LCD contrast	6. Settings:	The settings available are 1 to 20.
Baud rate	7. Rates:	The rates available are... 300; 600; 1200; 2400; 4800 and 9600.
TCI availability	8. TCI:	This display is for information only, the mode cannot be changed, it is set at manufacture to either... TCI PRESENT = YES or NO (i.e. TCI facility is either available or unavailable).
Mode	9. Settings:	This parameter can be set to: MODE = NORMAL MODE = TCI MODE = BOTH
Max Rate	10. Settings:	The configuration MAX RATE settings available are: 50; 100; 200; 400; 800 and 1200 ml/h. The software program of the pump automatically sets a maximum continuous infusion rate that depends upon the syringe size that the pump senses; see Table 1. This automatic continuous infusion rate will be overridden if the configuration MAX RATE is set below the automatic rate. For example, even though the maximum continuous infusion rate for the BD Plastipak 50 ml syringe is 400 ml/h (Table 1), if the configuration MAX RATE is set to, say, 200 ml/h then the syringe will only be able to infuse at up to 200 ml/h. Thus the configuration MAX RATE setting can be used to control, in preset steps, both the <i>continuous infusion</i> (up to 400 ml/h) and the <i>bolus infusion</i> (up to 1200 ml/h).

(contd.)

Table 2-1 Syringe size and max. auto. continuous infusion rate

Syringe size (ml)	Max. auto. continuous infusion rate (ml/h)
50/60	400
30/35	400
20	400
10	200
5	100

Diagnostic mode

WARNING

The diagnostic mode must only be used by appropriately qualified personnel

The 3500 has been designed so that the diagnostic mode parameters will only be available if a set sequence of pump buttons are pressed.

Calling up the diagnostic mode

With the AC power switched on and connected (or under battery power) press the **ON** button.

Press the second ▲ button from right and the **ALARM** button simultaneously.

i.e. press $\wedge \wedge \blacktriangle \wedge$ and **ALARM** simultaneously.

The display will show the following question:

DIAGNOSTICS ?

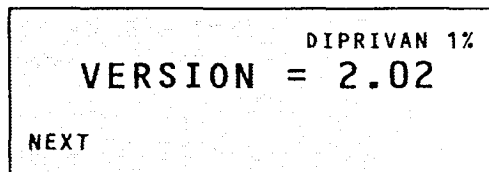
Within two seconds press the **START** button to confirm that you want to enter the diagnostics mode.

A display similar to the one shown below will then appear:

Note...

If the **START** button is not pressed within two seconds the pump will return to its 'set up' mode.

Diagnostic mode



Moving to the next parameter

Press the **NEXT** menu button in order to move to the next parameter.

Diagnostic displays

The six parameters that can be viewed, by scrolling through them when in the diagnostic mode, will be similar to the displays shown below:

- **VERSION = 2.02**
this display shows the version of software that is installed in the pump. Note, since the 3500 is field up-gradable via its serial port the version number on the label of the EPROM may differ from the installed version. The displayed version is to be taken as correct.
 - **CRC = E279**
this shows the Cyclic Redundancy Check (CRC).
 - **TCI VERSION = 1B**
this shows the software version of the TCI module (version displayed in TCI mode only).
 - **TOTAL VOLUME**
this shows the total volume infused (in decalitres) since the pump was manufactured.
 - **TOTAL HOURS**
this shows the total hours that the pump has been in operation since the pump was manufactured.
 - **VOLTAGE = 6.9**
this shows the value of the DC voltage that is supplied to the main board.
-

Exiting from the diagnostic mode

Press the **STOP** button when in any diagnostic parameter in order to exit from the diagnostic mode.

WARNINGS

The following procedures must only be carried out by qualified personnel.

Electric shock hazard

The pump *must* be disconnected from the AC power supply before opening the casing.

Disassembly and assembly of 3500 casing

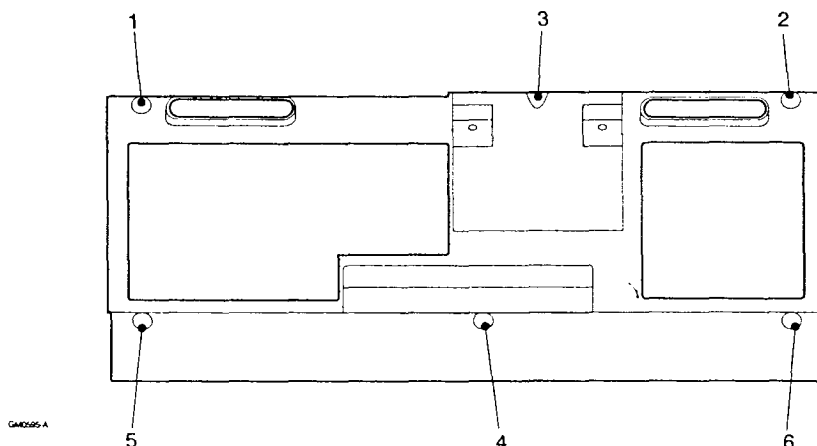
The casing of the pump will have to be opened in order to carry out any adjustments that may be required to the occlusion pressure, and also for various setting up and repair procedures. These procedures are detailed in Chapters 4 and 5.

Taking the casing apart

1. Disconnect the AC power connector and utilising a scratch free flat surface, turn the 3500 over in order to gain access to the base of the pump.
2. Undo and retain the six screws that hold the two halves of the 3500 casing together. One of the six screws is situated in a channel in the rear cover.
3. Place the pump upright and from the top carefully ease the two halves of the casing apart, taking care not to put any strain on the internal connecting cable looms that form a hinge between the two halves of the casing.

Assembly

4. Each time the casing has been taken apart and reassembled the *syringe size* functional tests detailed on page 6-1 must be carried out.
5. Being careful *not* to trap any leads, assemble the casing by reversing steps 2 and 3 detailed above, ensuring that the two case halves have 'snapped' together and that the front and rear mating edges are equal and parallel. The screws should be tightened to a torque of between 70 and 75 cNm and in the order shown in the diagram below:



Occlusion pressure and thrust

Infusion line measurements

Translation of the *thrust* produced by the 3500 into *pressure* in the infusion line depends on the syringe diameter and the stiction of the syringe. The formula for calculating this pressure is given below:

$$P = \frac{(T - S) \times 732}{A}$$

where: P is the delivery pressure in mm Hg.
T is the thrust in kg.
S is the syringe stiction in kg.
and A is the cross sect. area of the syringe in cm².

The occlusion *thrust* of the 3500 is *factory* set to be between two limits. The customer may reset the occlusion thrust for a required infusion line pressure, for particular applications. The occlusion thrust of any particular 3500 may, therefore, differ from the *factory* set level.

Since the occlusion *thrust* is related to the occlusion *pressure*, only the *thrust* or the *pressure* will need to be checked and if necessary adjusted. Graseby check and if necessary, adjust the occlusion *thrust*. The *thrust* checks and adjustments are detailed in the following sections.

An occlusion *thrust* adjusting nut is mounted on the lead screw. This nut is fitted with a grub screw. Rotating the adjusting nut increases or decreases the occlusion *thrust* setting.

Syringe stiction

Stiction for a syringe varies from brand to brand as well as from batch to batch. Stiction can be as low as 0.1 kg and as high as 2 kg.

The stiction of some syringe brands has been found to be particularly high.

Stiction can also vary along the plunger travel and is usually lower in small diameter syringes. Using a sample syringe and allowing for a safety margin for sticky syringes, adjustments can be made by measuring the *pressure* generated.

Alternatively, if the stiction characteristics of a syringe are known then by using the formula given above the occlusion *pressure* can be set by adjusting the *thrust* of the 3500.

Occlusion pressure

Using a new syringe of suitable size (a 60 ml syringe for most applications), and a pressure measuring device, run the 3500 at an infusion rate of 200 ml/h and ensure that occlusion occurs between the desired levels.

At the factory set occlusion level of between 5.7 kg and 6.2 kg, the occlusion *pressure* will be around 750 mm Hg for a BD 60 ml syringe.

Thrust checks

Set the plunger clamp to its mid position (approx.). Place the 3500 in a vertical position (left hand side uppermost, refer to Fig 2-1).

To ensure that the syringe size sensor is correctly positioned place the body of a syringe with its tip sawn off onto the 3500. The sawn off syringe also enables the weight measuring rod to be positioned through the *part* syringe onto the plunger clamp.

At an infusion rate of 200 ml/h carry out the following procedures in order to check the occlusion thrust:

1. Place a weight of 5.7 kg (± 250 g) on the plunger clamp assembly and check that the 3500 operates for at least 30 seconds and does **not** occlude (i.e. the alarm does not sound). Remove the weight.
2. Place a weight of 6.2 kg (± 250 g) on the plunger clamp assembly and check that within 30 seconds of placing the weight the pump **does** occlude.

Note: The above weights correspond to the factory set occlusion thrust levels. Some customers may require different weights for their particular applications.

Adjustments

If the thrust requires adjustment then the occlusion threshold adjustments detailed in steps 1 to 8 under the heading *Threshold adjustments* (page 2-11) will have to be carried out.

Adjusting the occlusion thrust

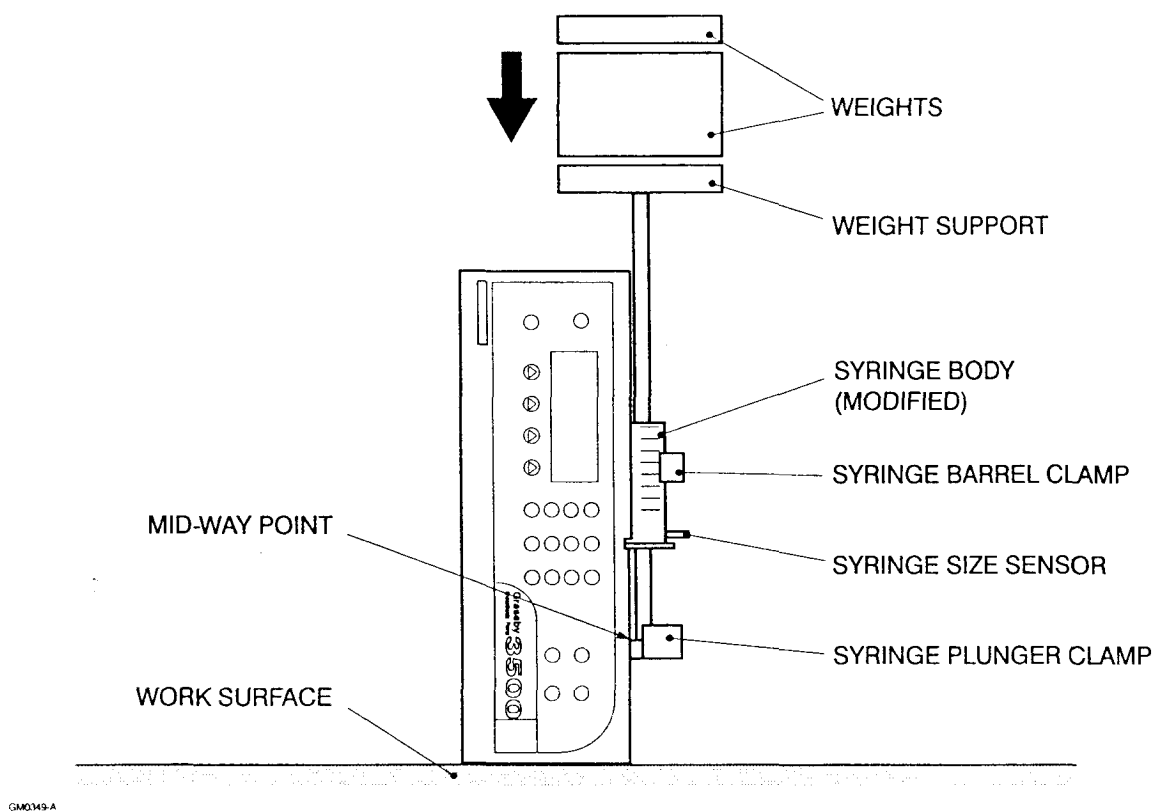


Figure 2-1 Setup for occlusion thrust checks

Threshold adjustments

If the occlusion *threshold* requires adjustment then the following procedures will have to be carried out:

1. Switch off the pump and disconnect the AC supply.
 2. Take the casing apart as detailed on page 2-7.
 3. If necessary rotate the leadscrew to reveal the grub screw that is located on the *occlusion* adjusting nut. Loosen the grub screw with a 1.5 mm hexagon key.
 4. Alter the setting of the *occlusion adjusting nut* as necessary. One full turn of the adjusting nut using a 50\60 ml syringe gives approximately 2.9 kg of adjustment.
 5. Tighten the grub screw.
 6. Temporarily assemble the two halves of the pump, connect the AC supply and switch ON. Carry out the Thrust checks (page 2-9).
 7. If necessary repeat steps 2 to 6.
 8. Completely assemble the pump casing (refer to page 2-7), being careful not to trap any leads.
-

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CHAPTER 3

FUNCTIONAL DESCRIPTIONS

Introduction

This Chapter explains how the 3500 operates. Reading this chapter will help a technician to rectify any possible faults that may occur within the 3500.

The functional descriptions of the 3500 may be divided into five separate areas, and each of these functional descriptions have been detailed separately in the descriptions that follow:

- Drive system.
 - Occlusion sensing system.
 - Electro/mechanical control system.
 - Sensing (alarm) systems.
 - Software.
-

Drive system

The motor, gearbox, leadscrew and associated components (Fig. 7-1) are mounted on a glass reinforced polycarbonate casing. The strength of this casing enables a precise mechanical location to be achieved for the various components.

Both the inner and outer metal tubes are made of substantial material in order to eliminate all unwanted flexing.

DC motor and leadscrew

The 3500 drive system comprises a dc motor working through a gearbox in order to rotate a *leadscrew*. A *half nut assembly* engages onto the *leadscrew*, and the *assembly* is also connected to a steel tube. The steel tube is in turn connected to the 3500 plunger clamp.

As the motor spindle rotates the *leadscrew* rotates and the *half nut assembly* travels to the left, along the *leadscrew*. The *half nut assembly* pulls the outer of two steel tubes to the left. This outer tube travels over and along a support tube; the support tube is the length of the 3500. The plunger clamp moves with the outer tube pushing 'in' the syringe plunger.

(contd.)

Functional descriptions

Processor	The DC voltage applied to the motor is derived from a pulse width modulated output from, and is controlled by, the processor.
Toggle mechanism	A spring-loaded <i>toggle mechanism</i> is attached to the bottom of the <i>half nut</i> . This <i>toggle mechanism</i> enables the 3500 plunger clamp to be physically swung 'in or out' thus rotating the outer metal tube so that the <i>half nut</i> is either fully 'engaged or disengaged' (respectively) from the <i>leadscrew</i> .
Plunger clamp	When the 3500 plunger clamp is pulled down the <i>half nut</i> engages with the <i>leadscrew</i>, and the clamp itself engages with the end of the syringe. The syringe plunger slots into place behind a slotted pair of lips. These lips prevent the syringe plunger from moving forward in the event of negative pressure on the syringe. Two small push-buttons on the edge of the 3500 plunger clamp make contact with the top of the syringe plunger. These push-buttons control the operation of a <i>lever</i> which protrudes from the 3500 plunger clamp. When the push-buttons are pressed in, by coming into contact with the top of the syringe, the <i>lever</i> becomes free and is able to retract into the 3500 plunger clamp. This retraction takes place when the plunger clamp is physically swung into its down operating position. If the push-buttons are not pressed 'in' the <i>lever</i> will be locked in its protruding position thus preventing the 3500 plunger clamp from being pulled down. This in turn prevents the <i>half nut</i> from engaging on the <i>leadscrew</i>. This push-button safety system prevents the <i>leadscrew</i> from being engaged unless the top of the syringe is correctly positioned in the 3500 plunger clamp. If the 3500 plunger clamp is accidentally dislodged during an infusion, the pump will stop infusing and the alarm will sound.

Occlusion sensing system

Clutch assembly and opto-sensor

The occlusion sensing system consists of a back pressure sensing system (clutch and spring mechanism) with a rotation detector (slotted disk plus opto sensor). The clutch and rotation detector are located at the left hand end of the leadscrew, the spring is at the right hand end of the leadscrew.

The clutch is held engaged by the spring with a pressure sufficient to overcome any resistance from the syringe plunger and the normal back pressure from the infusion line. The rotation detector will generate an output when the leadscrew rotates.

If there is an occlusion in the line then the back pressure will rise as the pump attempts to force fluid through the line. When there is sufficient pressure to overcome the spring pressure (factory set at 800 mm Hg.) then the leadscrew moves to the right, losing contact with the clutch. The rotation detector no longer generates an output which results in an occlusion alarm.

Occlusion detection

This method of occlusion detection is extremely sensitive as it is the *lack of pressure* on the clutch that generates the alarm, rather than the detection of the *movement* of the leadscrew as used in traditional designs.

UK patent number 2249 497.

Electro/mechanical control system

Motor speed

The processor outputs a Pulse Width Modulated (PWM) signal which has a mark-space ratio proportional to the required speed of the DC motor. The motor interface circuit outputs a dc voltage which is varied by the PWM signal.

A Hall effect sensor is attached to the motor shaft and is used to provide a feedback signal. This feedback signal enables the processor to change the PWM signal, thus altering the speed of the motor.

Motor rotation

Rotation of the occlusion slotted disc described above is also used in conjunction with a second sensor, to monitor the rotation of the motor. If either sensor does *not* detect the appropriate pulses an alarm signal will be generated.

Mechanical characteristics

The mechanical characteristics of the system are:

- Gearbox reduction ratio: 150:1.
 - Leadscrew pitch: 1.587 mm.
 - Syringe characteristic: 1 ml/1.8 mm (BD 60 ml syringe).
-

Sensing (alarm) system

Introduction	In addition to the occlusion sensing system (page 3-3) the following sensing systems are also operative within the 3500.
End of infusion	A metal flag protrudes from the left hand side of the half nut (in parallel with the leadscrew), this is the nearly empty flag. As the syringe plunger nears the end of its travel this flag activates an opto-sensor at the left hand end of the leadscrew. When the processor detects that this sensor is active and the slotted disc is no longer rotating it generates an end of travel <i>alarm</i>.
Syringe nearly empty	When the the nearly empty flag activates the opto-sensor and the slotted disc is still rotating the processor makes a calculation (dependent upon the infusion rate) and issues an alarm three minutes before the end of the infusion.
AC power failure	The sensing system will detect an AC power failure. The 3500 will continue to run after a power failure for a period of ten hours or more, by switching to the internal battery supply.
Battery voltage low	The sensing circuits incorporate a system that monitors the output of the batteries and registers an alarm if the voltage of the batteries drops below 5.75 V. If the voltage falls below 5.4 V the 3500 will turn itself off after an initial warning period.
Self tests/pump malfunction	Various 'self tests' are carried out on the 3500 when it is first switched ON . In addition to the self tests the rotation of the slotted disc at the end of the leadscrew is monitored to ensure that the drive mechanism is operating correctly.

Drive disengaged, or syringe not fitted

The 3500 drive system is designed so that it is only engaged when the top of the syringe is correctly positioned in the 3500 plunger clamp. If the plunger clamp is knocked out of place during an infusion the 3500 drive will automatically stop (the dis-engagement of the half nut is detected by an opto-sensor).

Also, trying to operate the 3500 without a syringe or with a syringe incorrectly fitted will cause the 3500 to go into an alarm state.

Syringe sizing system

The 3500 syringe sizing system comprises a flag moulding (Fig. 7-2) that rests on the barrel of the syringe, and in conjunction with two size sensors (Fig. 7-6) measures the diameter of the syringe being used.

The flag moulding rotates about the outer of the two guiding tubes and moves an actuating flag between the three size sensors.

The flag is able to activate the size sensors as follows:

- Either sensor.
- Both sensors.
- Neither sensor.

Depending on the operation of the size sensors the 3500 monitors the size of a syringe as being 5 ml, 10 ml, 20 ml, 30 ml or 50/60 ml.

Alternatively, if a syringe is not fitted onto the 3500 or a syringe smaller than 5 ml is fitted, then the *syringe invalid* alarm will be activated.

Functional descriptions

Software

Design methods The software for the 3500 has been designed using the structured design methods. The software incorporates many safety tests and consistency checks. The source code for the processor is written in Modula 2 which is particularly suitable for safety-critical design.

Self tests The 3500 self tests include the following:

- CPU test.
- ROM test (16 bit CRC).
- RAM test.
- Power supply voltage test.
- Keyboard test. This test checks for shorted keys.

The pump's settings are stored in EEPROM in the processor.

CHAPTER 4

CIRCUIT DESCRIPTIONS

Introduction

This Chapter describes the action of the circuits that are used to operate the 3500 and also shows the associated circuit diagrams and circuit board layouts.

The 3500 contains six separate circuit boards, as follows:

- Main board.
- Regulator board.
- TCI module.
- Syringe size sensors board.
- Opto-sensors board.
- Distribution board.

The overall block diagram for the 3500, showing the inter-connections between the various circuits is given on Fig. 4-1.

The Syringe size sensors board (Fig. 4-17 and 4-18) and the Opto-sensors board (Fig. 4-19 and 4-20) provide a mounting base for the sensors and also junction points for their outputs.

The Distribution board (rear casing) is used to link the Regulator board, the two Sensor boards, and the serial interface port to the Main board (front casing) via a 26 way cable (Fig. 7-1).

The six circuits are individually described in the sections that follow.

Main board circuit

Sub-circuits

The Main board circuit is shown on Fig. 4-2 and comprises the following sub-circuits. These sub-circuits are individually described in the sections that follow:

- Processor core.
 - Motor interface.
 - Power control.
 - Sensors interface.
 - Communications (RS232) interface.
 - TCI module interface.
 - Input/output interface.
-

Processor core circuit

Description

The Processor core circuit (Fig. 4-3) forms part of the Main board circuit and is used to process all the 'operating activities' of the 3500.

The processor (IC12) has an on-chip EEPROM which stores the latest settings of the pump, e.g. the syringe brand.

IC12 also incorporates the following:

- On-board RAM.
- An Analogue-to-Digital converter (A to D).
- Timing circuitry.
- Four pulse width modulated outputs.
- Communications circuitry.
- An internal watchdog.

Description
(contd.)

IC9 is a 512kbyte flash EPROM device which is addressed by the processor's decode logic as 16 pages of 32k each. A small portion of the EPROM device is reserved by the system for a bootloader program which is capable of programming the rest of the device from data supplied via the pump's RS232 interface. The remainder of the device stores the pump's system software. The entire pump operating software may be re-programmed via the RS232 port.

Pins 70 and 71 on IC12 control the operation of the processor and both signals are held *high* in order to set the processor to address IC9 for its operating software.

Pins 44 and 43 on IC12 are held at Vcc and ground (respectively) as the reference inputs to the processor's built in A to D converter.

The chip IC10 is the processor's supervisory circuit, which has the four following main duties:

- To control the processor reset.
- To provide the switch over battery backup for the RAM.
- To provide the watchdog timer.
- To provide the CMOS RAM write protection during power down.

Pin 21 of the processor receives pseudo non-maskable interrupts generated by the supervisory circuit in the event of a system fault being detected.

The crystal X1 and the associated components R63, C28 and C29 form a 16 MHz oscillator to provide clock pulses for the processor, via pins 67 and 68.

(contd)

Motor interface description

Description (contd.)

The ram chip (IC8) is used as a buffer for the RS232 interface and the display, and general purpose storage area.

A Pulse Width Modulated (PWM) output on pin 12 (PW1) is used to control the DC motor power.

Output PW3 on pin 14 controls the sounder.

Output PW4 on pin 15 controls the LCD screen contrast.

Motor interface circuit description

Introduction

IC12 utilizes a closed loop power controlled system to regulate the speed of the DC motor. A Pulse Width Modulated output signal (PW1; pin 12; Motor Drive) is used for this regulation. This system results in very accurate control over the rate that the drug is administered.

Motor current control

Power control transistors Q11 and Q12 (Fig. 4-4) in conjunction with resistors R33, R36 and R37 allows the 5 V PW1 signal to control the 7 V supply (DCSW).

Thus supply DCSW is switched on and off by the power control circuit. R42 protects the power supply from short circuiting if Q11 and Q12 are both active at the same time.

The motor windings are connected to Vin, so the transistor Q8A will be activated by the presence of the signal ENABLE_MOTOR. For the motor to run, Q8A must be active, thus making a motor circuit interlock.

The 7 V DCSW PWM signal provides the inputs to Mosfet's Q10A and Q10B. These two power Mosfet's when conducting enable the motor to draw a high PWM current from the 7 V DC supply (Vin).

Transients; suppression

L2 and C17 smooth the high PWM current to a level that is acceptable for motor operation. Reservoir capacitor C21 reduces excessive peaks on Vin. C18 prevents transients from DCSW affecting the operation of Q11 and Q12.

Motor speed control

To close the control loop, the motor speed is monitored by a hall effect sensor on the back of the motor shaft. The signal is detected by R41, R40, R74, and IC15F before being fed back to the processor.

IC12 measures the frequency of this feedback signal and if the signal is outside the limits required for the speed of rotation, then IC12 will change the duty cycle of the PWM output.

By using this feedback system the speed of the motor can be closely controlled to within set limits.

Power control circuit

Logic circuit supply; Vcc

Chip IC4 (Fig. 4-5) is a linear regulator which provides a 5 V DC supply (Vcc) for the logic circuits. C14 and C10 are decoupling capacitors.

IC5B and IC5C form a set/reset latch to operate the power MOSFET Q8B. The latch is triggered by a *high* pulse (POWEROFF) from the processor, causing Q8B to turn off and disconnect the power.

When tripped, the latch cannot be reset by the processor; the reset is by a *high* pulse from the keyboard by pressing the **ON** button.

Q7, R28 and R29 form a logic level translator to raise the 0 to 5 V logic levels to 0 to 7 V logic levels for IC5C, which has a permanent 7 V supply.

C15, C16, R28 and R30 overcome the effects of any transients.

D19 prevents C16 from discharging into IC5B in the event of Vdd being removed.

RAM and clock supply

The supervisor chip (IC10) transfers the power for the RAM and the Real Time Clock (RTC) from the regulated 5 V supply Vcc to Vcc' when the main power, and hence Vcc, is turned off. This preserves the memory held in RAM and also keeps the RTC running.

R31; R26 and C11; bandgap references D20 and D21; and transistor Q6, supply a constant voltage, Vcc', of 3 V.

Sensors interface description

Sensors interface circuit

Introduction

The six opto-sensors (Fig. 4-17 and 4-19) used in the 3500 are multiplexed onto three lines into the processor, and are used to carry out sensing functions that include the following:

- Syringe size sensing.
- Whether the syringe clamp is open or closed.
- The rotation of the slotted disc used for detecting an occlusion.
- If the syringe is nearly empty.

The syringe size sensors board and the opto sensors board are detailed on page 4-16.

Circuit description

Q14 (Fig. 4-6) activates the size sensors LEDs.

Q15 activates the status sensors LEDs.

The software determines which of the two transistors is active at a given time. R59; R60; R61 and R62 are current limiting resistors.

The opto-detection circuit uses R56 to R58 as pull-up resistors, and uses R52A to R52D; R53 and R54 as current limiting resistors.

Zener diodes D22 to D24 are used for electrostatic discharge protection.

When a photo transistor detects the LED associated with it, the line OPTO_0; 1; or 2 will be pulled *low*, this signal is then input to the processor via SENSE1; 2; or 3 (respectively).

When SENSE0 is *low* it indicates that the mains supply is present. R50; R51; R55 and Q13 enable the processor to detect the presence or absence of the AC supply.

R48; R49 and C27 act as the low battery voltage sensing circuit. R48 and R49 act as a potential divider enabling the voltage between them to be input to the A to D converter on the processor.

RS232 Interface circuit

Introduction The processor generates an RS232 compatible signal, with a 0 to 5 V output. Chip IC7 (Fig. 4-7) together with the components L3; R47; C22 to C26 converts this 0 to 5 V input signal into two higher level outputs; +10 and -10 V.

Circuit description IC7 is supplied with a single +5 V power rail, and uses two charge pumps to create a +10 and a -10 V supply.

The communications protocol description may be obtained from Graseby Medical (Customer Care).

The signals on the 'D' connector are shown on Fig. 4-23, and the pin connections for the 'D' connector are shown below:

Table 4-1 RS232 'D' connector connections

Pin number	Connection
1	Not connected
2	RxD
3	TxD
4	Not connected
5	GND
6	DSR (handshake out)
7	RTS (+10 V out)
8	CTS (handshake in)
9	Not connected

TCI module interface circuit

Introduction

The 3500 incorporates a Zeneca *module* interface board (Fig. 4-8) that in conjunction with a Zeneca PFS enables a Target Controlled Infusion (TCI) to be administered.

The *module* has been developed by Zeneca and is treated by the Graseby system as a 'black box'. If the *module* becomes faulty then it must be renewed.

Using a radio frequency based technology and a small aerial situated within the 3500, the recognition tag fixed to one of the ears of the Zeneca PFS greatly reduces the risk of an incorrect infusion of an inappropriate pharmacokinetic model.

The TCI subsystem has the following features:

- Appropriate infusion rates are generated by a fast 16 bit microprocessor using a full solution to the pharmacokinetic model
- An independent 8 bit processor checks the infusion using a different solution to the same pharmacokinetic model.
- The syringe recognition system utilises a non-contact radio frequency technology to ensure that the system is immune to blood, iodine and other substances commonly found on infusion pumps.
- Effects of a subsystem failure are limited by the use of a master-slave communication protocol and a serial communication interface.

(contd.)

Circuit description

The pump's processor communicates with the *module* via the RS232 interface. The *module* sits between the processor's serial communications I/O and the pump's RS232 line driver (IC7). When the pump's processor is required to talk to the connector port, it does so by passing characters through the *module*.

The communications protocol between the pump and the *module* allows the pump to specify the destination for the communications (i.e. for action by the *module* or for transparent passthrough).

All commands for the pump from the *module* are transmitted to the pump's processor, upon the processor's request.

The motor speed feedback signal is also connected to the *module* as an additional check that the pump is behaving as the *module* expects.

IC13 gates the signals to the *module*. Normally, it leaves the *module* connected as described above.

It can, however, bypass the *module* altogether upon request from the pump's processor on the TCI_MODULE_BYPASS control signal. This would be used when the pump's software determines that the *module* has not been fitted, thus requiring direct communication with the RS232 port.

Main board input/output description

Input/output circuit

Front panel interface

The user interface is via the 22 button membrane front panel.

Pressing the **ON** button completes the circuit between pins 1 and 2 on PL2 (Fig. 4-9) and resets the latch that switches the DC power on.

The remaining buttons use a 6 x 4 matrix.

The 6 matrix rows, on pins 3 to 8 of PL2 (inclusive) are pulled *high* by resistors R14B; R14D; R15B; R15D; R16B and R16D and each row is connected to a membrane button and also to the microprocessor.

The four columns of the matrix, pins 9 to 12 on PL2 (inclusive), are connected to IC1, the parallel out serial register. As each column is pulled *low*, the status of each button in that column is input to the processor.

R22 limits the current in the control lines out of IC1. Diodes D8 to D11 allow IC1 to pull the selected control line *low*, but let the remaining lines float when a logic *high* is applied at the output of IC1. Zener diodes D13 to D18 (inclusive) and resistors R14A; R14C; R15A; R15C; R16A and R16C form the electrostatic discharge protection circuit.

LED illumination

The other four output lines on IC1 are used to activate transistors Q1; Q2; Q3 and Q5. Q1 to Q3 control the illumination of the display LEDs D2, D3 and D4.

Q5 with associated components D5, D6, R11 and R4 sinks a constant current from pin 18 on LCD1, thus illuminating the LED used to backlight the LCD display.

LED D1 is lit when there is a voltage on VAC, which signifies that the AC supply is connected.

(contd.)

Main board input/output description

Real time clock	IC3D acts as an inverter to input IO_CLR so that IC1 has its outputs disabled when the real time clock (IC11; Fig. 4-3) is reading data to or from the processor. IC1 and IC11 share the same data lines.
Liquid Crystal display	The 192 x 64 pixel, dot matrix liquid crystal display, is made up of three sections controlled by three drivers. Which driver is used for the data lines DB0 to DB7, on the data bus in LCD1, is controlled by the signals DISPLAY 11 to 13 from the processor. DISPLAY 11, which is connected to pin 16 on the processor, is the master display enable line. DISPLAY 12 and 13 define the section to be activated. The contrast of the display is controlled by the voltage on pin 5 of LCD1. This voltage is produced by the inverting switching regulator, IC2. The feedback reference voltage used by IC2 is varied by filtering the CONTRAST signal, a PWM output from the processor, this allows the contrast to be set by the user when in the configuration mode. Thermistor RT1 compensates for fluctuations to the display contrast, due to temperature changes.
Sounder	The supervisor chip IC10 (Fig. 4-3) is able to turn on the sounder independently of the processor by using the DIRECT_SOUND signal. The sounder is turned on if the processor malfunctions and is unable to produce its own sounder control. The above is achieved by the watchdog on IC10 producing a timeout, thus generating a DIRECT_SOUND control. D12 prevents a low signal from the SOUND signal drawing a current from IC10. Q4 and the associated components C3, R6, R12 and R17 constitute a low pass filter which allows the PWM signal (SOUND) from the processor, to activate the sounder. The sounder is connected to plug PL1.

Umbilical and distribution board connections

Umbilical cable connector

The umbilical ribbon cable connector (Fig.4-10) enables data, and the circuit power supplies, to be sent between the Main board and the Distribution board. The Distribution board is situated on the rear case moulding.

This method of design means that only the ribbon cable and the batteries connector link the two case halves, thus facilitating, when required, ease of servicing.

Distribution board connections

The Distribution board (Fig. 4-11) routes data between each of the other boards within the pump, and transfers this data to the umbilical ribbon cable connector.

Regulator board circuit

Introduction

The 3500 utilizes a *primary switching* power supply, as shown on Figures 4-12, 4-13 and 4-14, thus allowing the pump to operate with an AC input voltage between 100 V and 250 V.

The advantages of this type of power supply over a conventional power supply include the following:

- Greater efficiency.
- Larger power capability for a given size of power supply.
- A smaller transformer is needed for a given output power.

The operation of the Regulator is based upon a universal switch mode controller, IC1 (Fig. 4-13), which uses current mode pulse width modulation control.

The Regulator provides the following d.c. supplies:

- 7 V for the motor supply and the LEDs.
- 5 V for the logic circuits.

Live circuit and T1 primary description

The AC input supply is applied to the *live* circuit (i.e. the primary side of T1) via protection fuse FS2 (500 mA; Fig. 4-13) to the filter R20 and L2. The output from bridge rectifier D7 is smoothed by C10, and the transient current is limited by varistor V1.

When V1 is cold the resistance is high, and as the thermistor warms up the resistance decreases allowing the current to increase. The resulting output is used to start up IC1 via pin 1, and is also fed to the primary winding (pin 6) of the power transformer.

Once the switch mode controller has been started it obtains its supply from the bootstrap winding of T1, pins 2 and 3. This supply is smoothed by C13 and regulated by Zener diode D6.

The PWM signal output from pin 5 on IC1 controls the operation of Q3, which cycles on-and-off thus regulating the flow of current through the primary winding of T1, connected between OUT1 and OUT2.

Transient suppression is applied (Fig. 4-12) by C1/R1; C2/R2; C3/R4 and C4/R3.

(contd.)

Regulator board description

T1 secondary and isolated circuit description

The voltage at the secondary of T1 is rectified and smoothed (D1, D3, C6 and C7; Fig. 4-14).

The DC outputs are protected by fuses FS1 and FS2.

Batteries circuit

When the AC supply is being used there will be a DC voltage on pin 4 of PL11, thus allowing R6 and R7 to act as a potential divider in order to control Q2. Q2 will not be active if the AC supply is not present, this prevents the batteries from discharging through R8, R9, RV1 and R10.

When Q2 is active, the above components form a potential divider between the output of D3 and 0V. The output from the potential divider is used as the reference voltage for the shunt regulator D4.

C8 is a transient suppressor. Thermistor TH1 varies the reference voltage according to temperature, thus compensating for battery charging characteristics.

When the voltage at potentiometer RV1 exceeds the reference value, D4 conducts and activates the opto-coupler, IC2 (Fig. 4-12), and the current through this photo-transistor causes a voltage to be developed across resistor R19. This voltage is applied to IC1, which changes the mark-space ratio of the output signal (pin 5).

Overvoltage protection

The Regulator is safeguarded from an overvoltage by a crowbar protection device. When the output voltage exceeds 13 V the Zener diode D2 conducts, thus causing a voltage to be developed across R5. This voltage is used to activate the silicon controlled rectifier Q1, which will sink enough current to result in fuse FS1 blowing.

Plug PL11 outputs

The outputs at plug PL11 should be as follows:

Pin	Output
1 and 2	Ground
3	7 V DC when on AC or battery supply
4	7 V DC when on AC supply

Setting RV1 The procedure for setting RV1 is as follows:

1. Switch off the external AC power, remove the 3500 AC power connector and open the casing as detailed on page 2-7.
2. Remove plug PL11 and PL12 from the Regulator board and connect a 68 ohm, 1 watt resistive load across pins 2 and 3 of plug PL11. Pin 1 of PL11 is the top pin, as shown on the Regulator component layout diagram, Fig. 4-16.

Note: A Molex connector (part number 3750-7217) will enable the 68 ohm resistor to be easily connected across PL11.

WARNING
During the setting of RV1 dangerous AC supply voltages will be present.

3. Connect and switch on the AC power. If necessary, adjust RV1 to give a DC voltage across the 68 ohm load, dependent on the temperature, as shown in Table 4-2. RV1 is located near the bottom left hand corner of the board (see Fig. 4-16).

Table 4-2 Temperature/voltage range for setting RV1

Ambient temperature (° C)	DC output voltage (68 ohm load)
28	7.015
27	7.027
26	7.038
25	7.050
24	7.062
23	7.073
22	7.085
21	7.096
20	7.108
19	7.120
18	7.131
17	7.143
16	7.154
15	7.166

(contd.)

Sensors boards

Setting RV1

(contd.)

4. Switch off the AC power; remove the 68 ohm load; reconnect PL11 and PL12 to the Regulator board and assemble the casing as detailed on page 2-7.
-

Size sensors and board

The Syringe size sensors board (Fig. 4-18) is located just in front of the right hand end of the leadscrew (Fig. 7-1). The sensor moulding houses three infra-red emitting diodes and three photo-transistors.

These three pairs of detection sensors (Fig. 4-17) are used to detect and monitor the size of the syringe that is fitted onto the pump.

The ribbon cable from PL1 connections on the Size sensors board is routed to plug PL7 on the Distribution board.

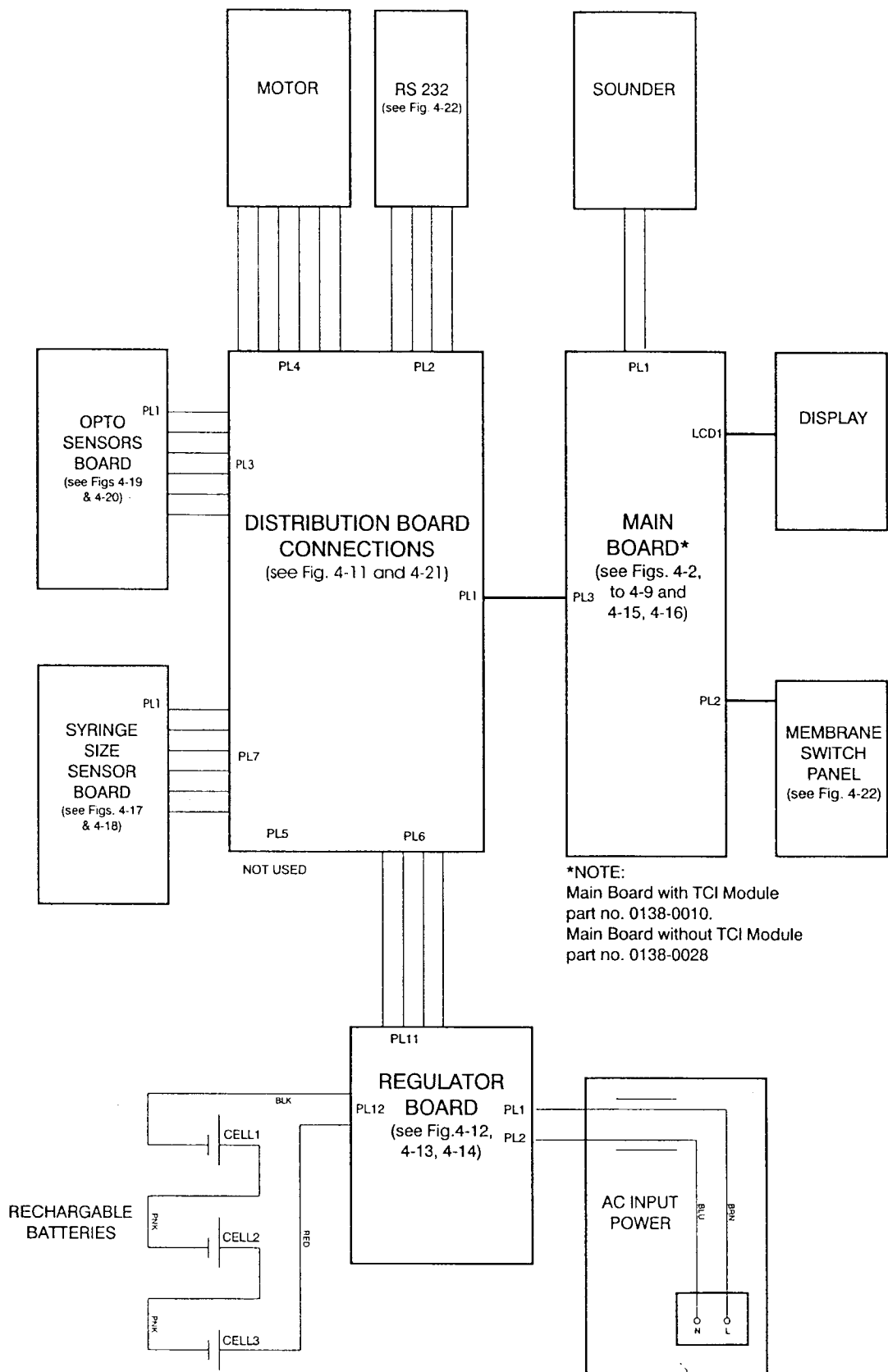
Opto sensors and board

The Opto sensors board (Fig. 4-20) is located on the left hand side of the pump, just above the left hand end of the leadscrew (Fig. 7-1). There are three optical interrupt devices attached to this board.

The three optical sensors (Fig. 4-19), opto interrupter 00, 01 and 02, are used to monitor the status of the three following parameters:

- End of syringe travel detection.
- Occlusion detection.
- Drive engagement detection (half nut on/off leadscrew).

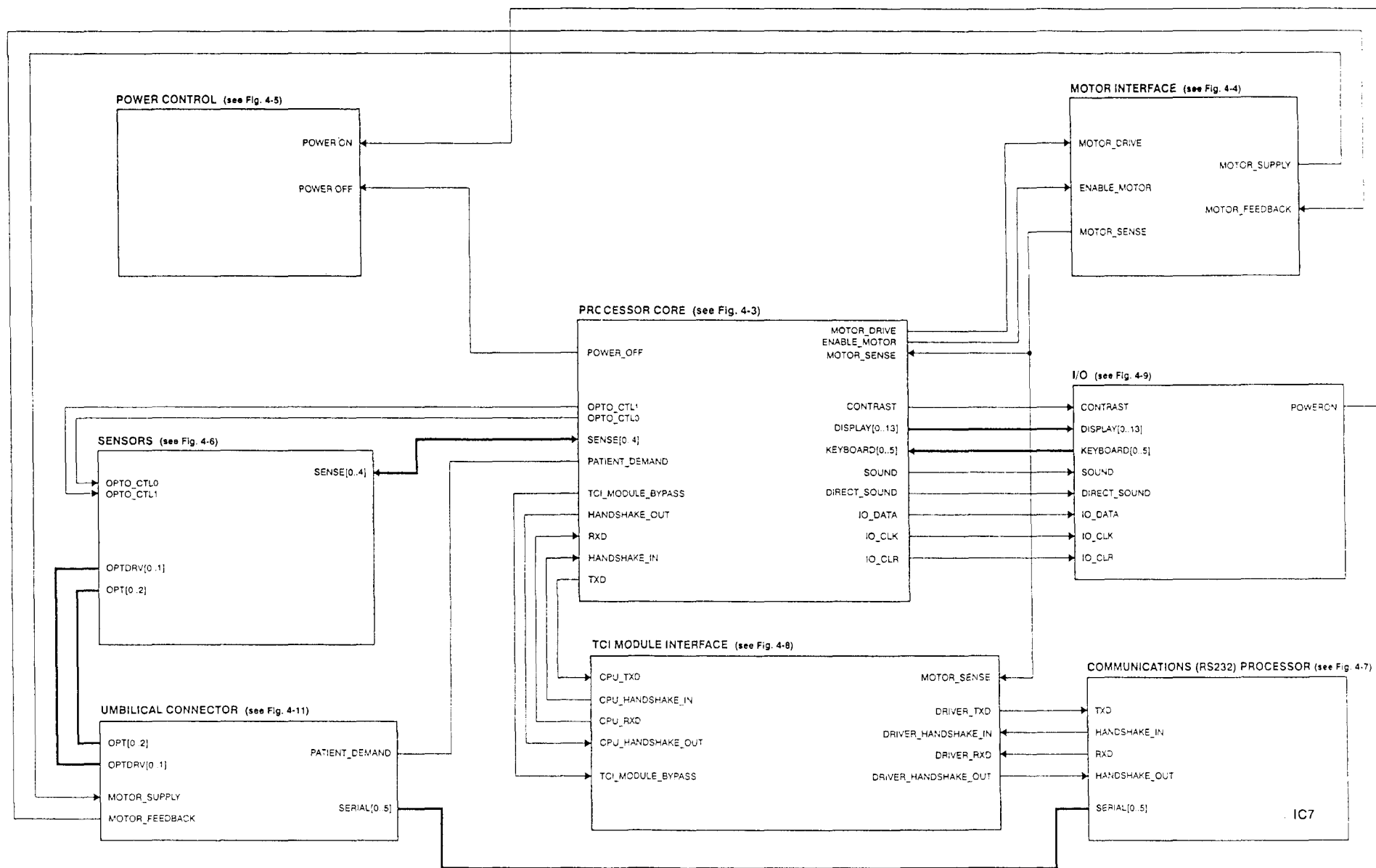
The sensors are hardwired from plug PL1, on the Opto sensors board, via a ribbon cable to plug PL3 on the Distribution board.



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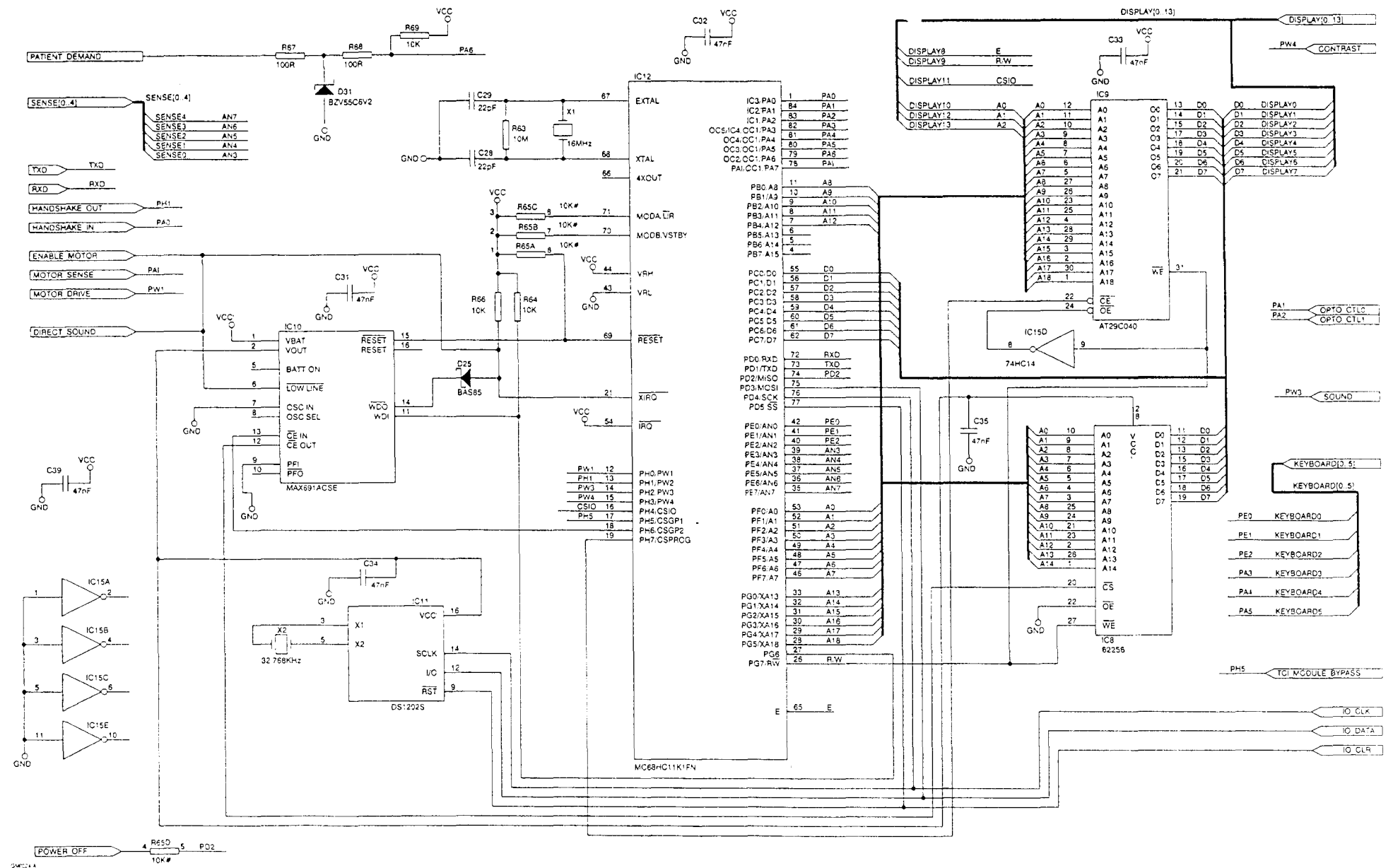
Figure 4-1 Overall block diagram of 3500 system

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GWC321 4

Figure 4-2 Main board block diagram



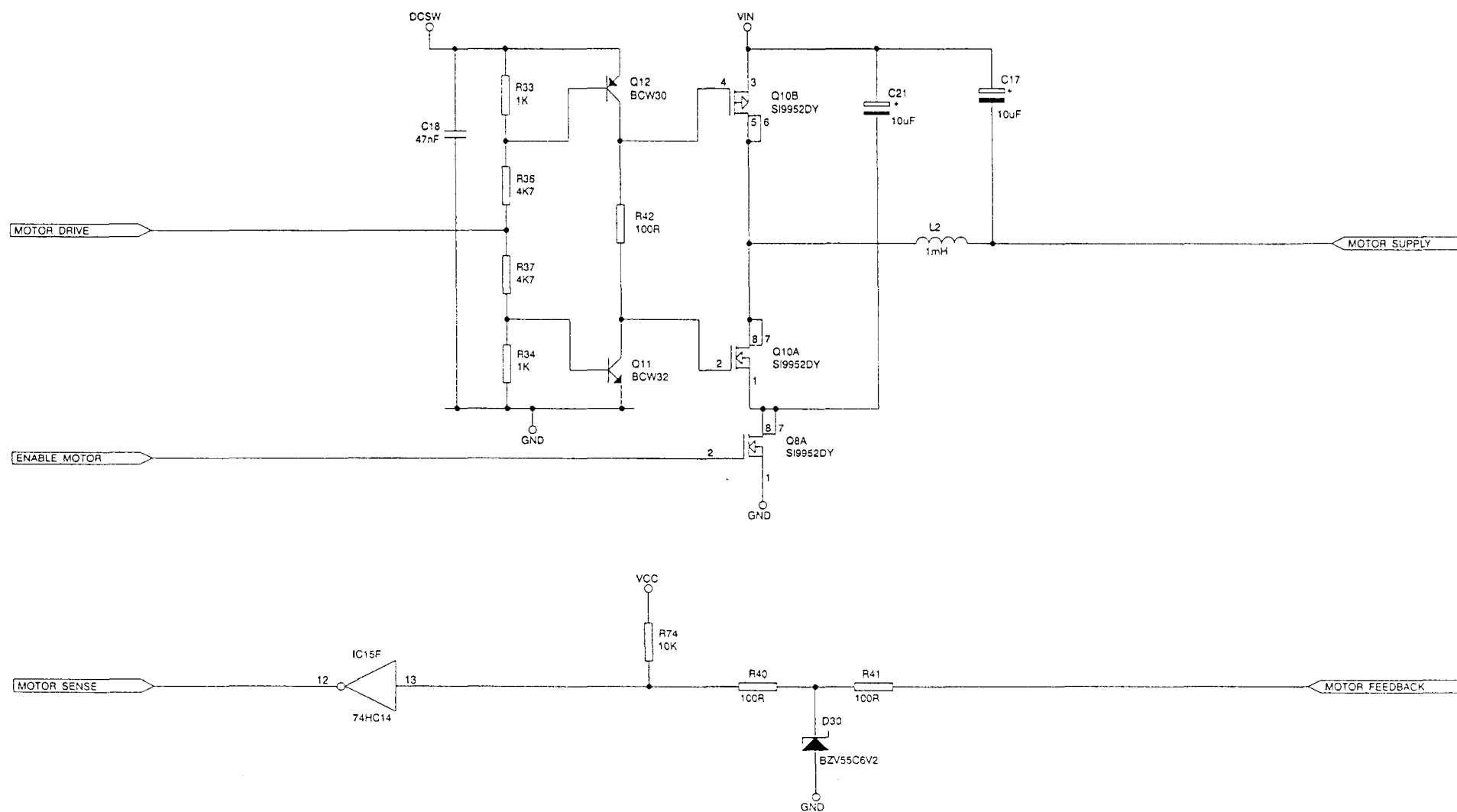


Figure 4-4 Motor interface circuit diagram

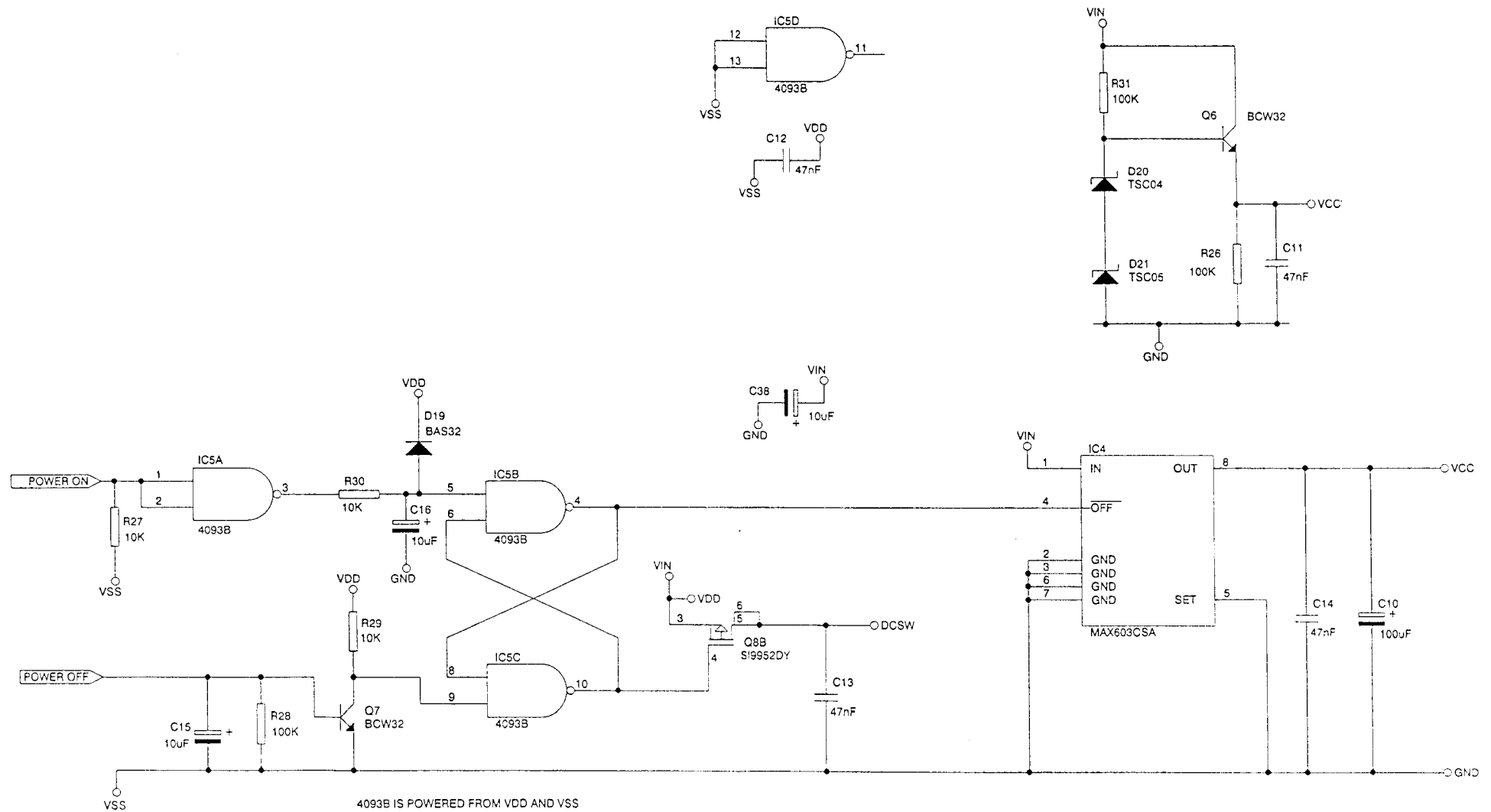


Figure 4-5 Power control circuit diagram

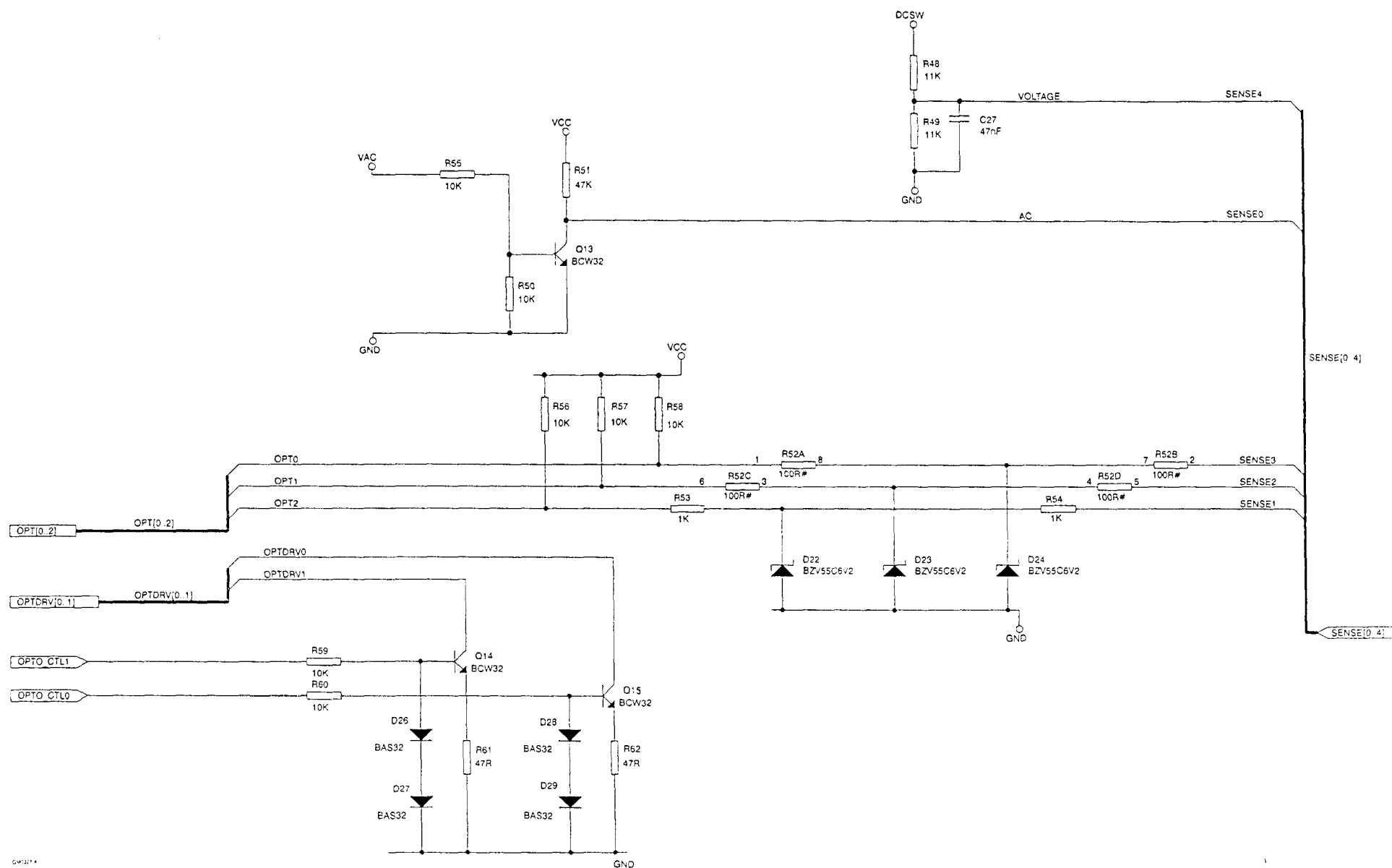


Figure 4-6 Sensors interface circuit diagram

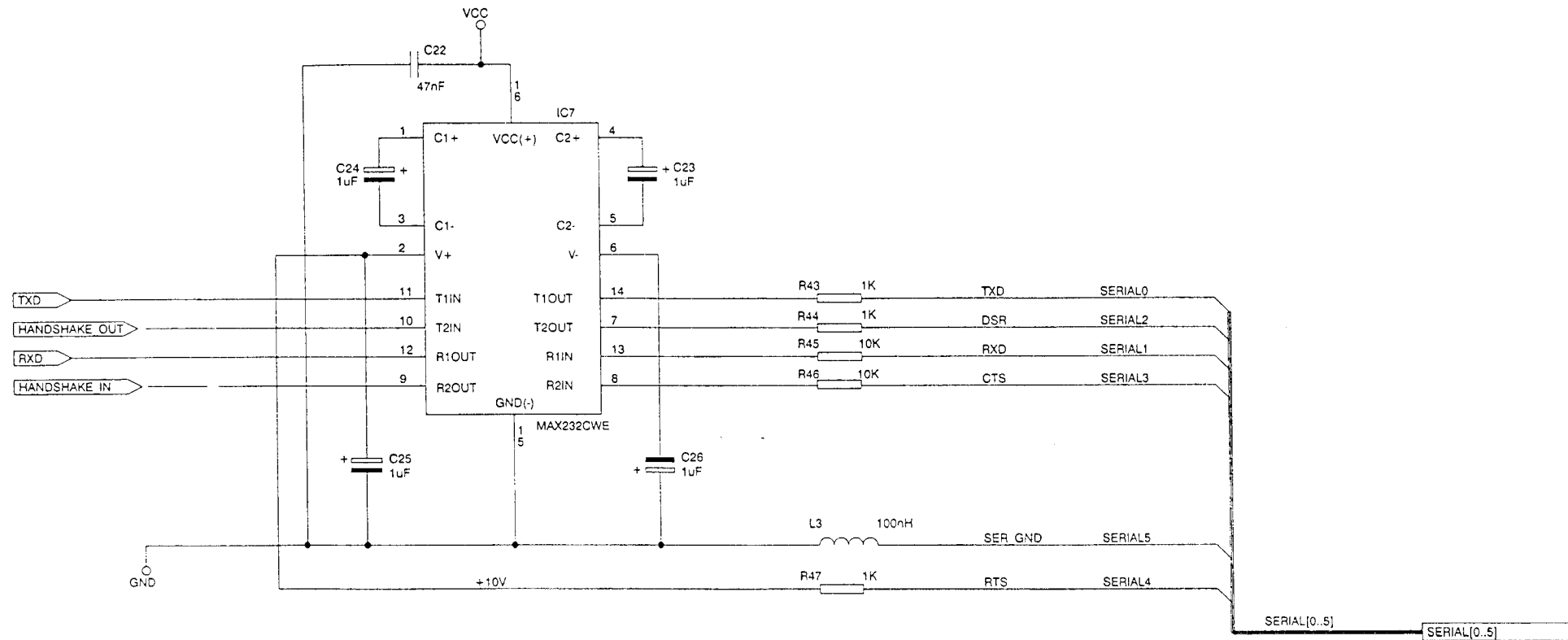


Figure 4-7 Communications (RS232) circuit diagram

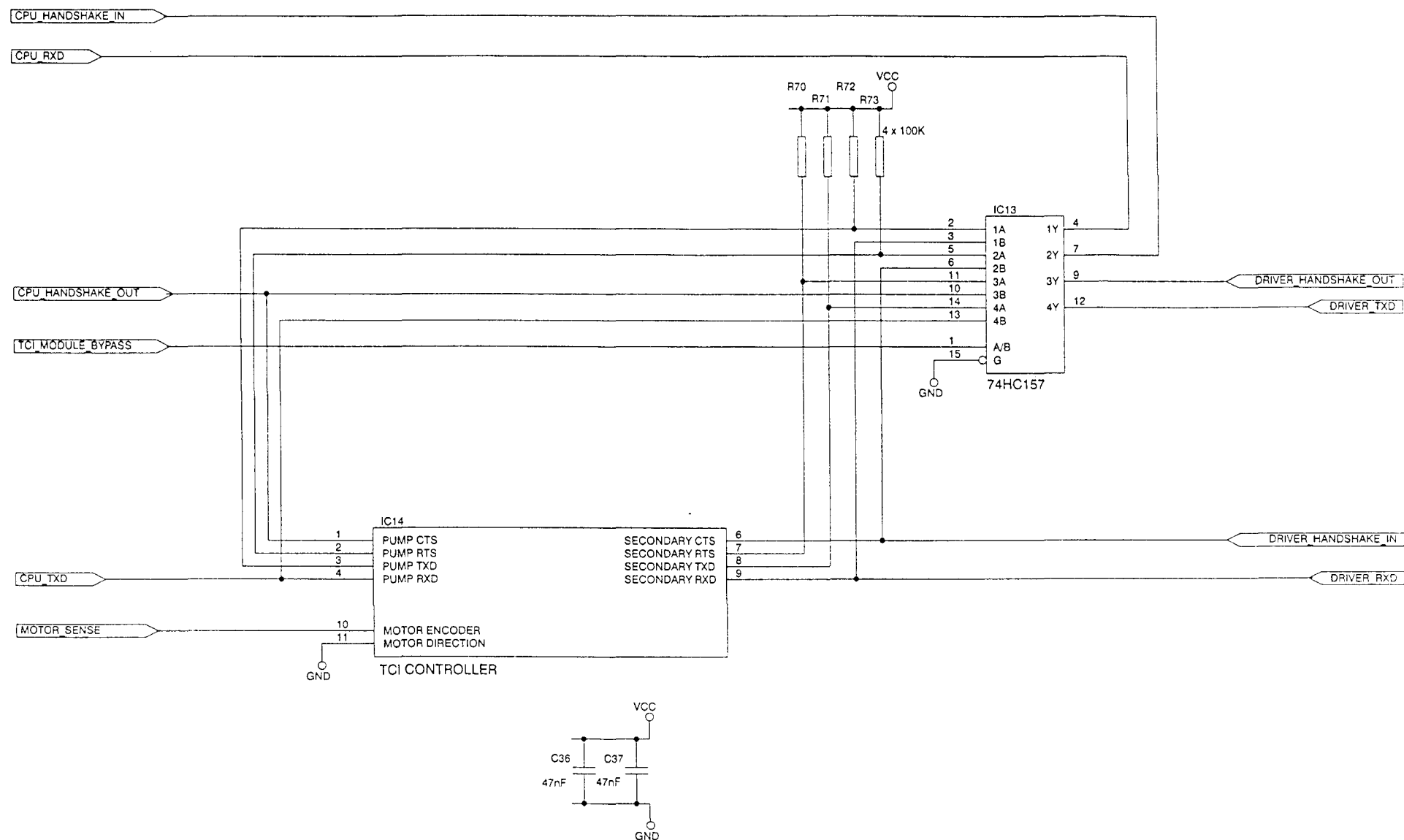


Figure 4-8 TCI module interface circuit diagram

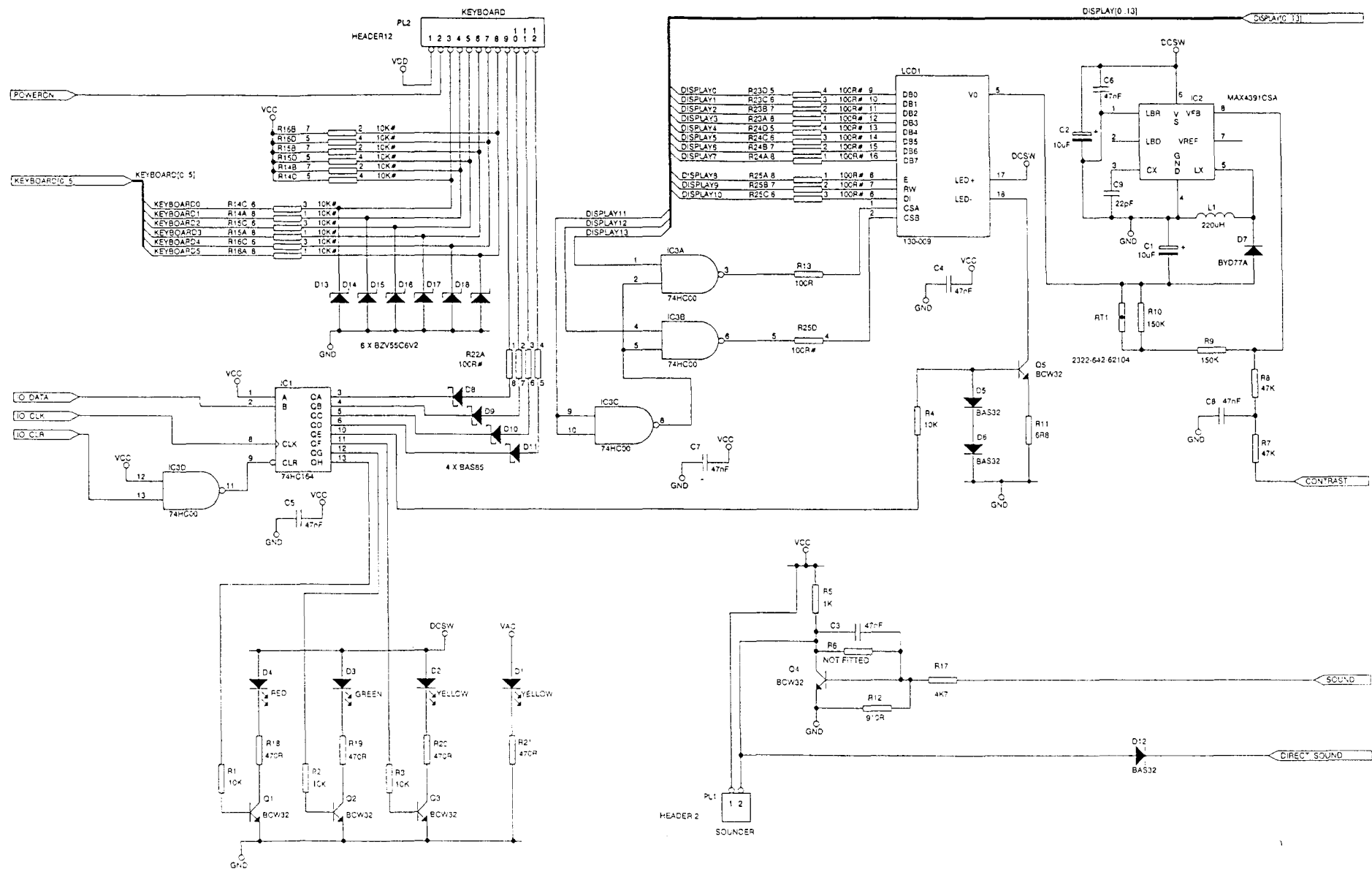
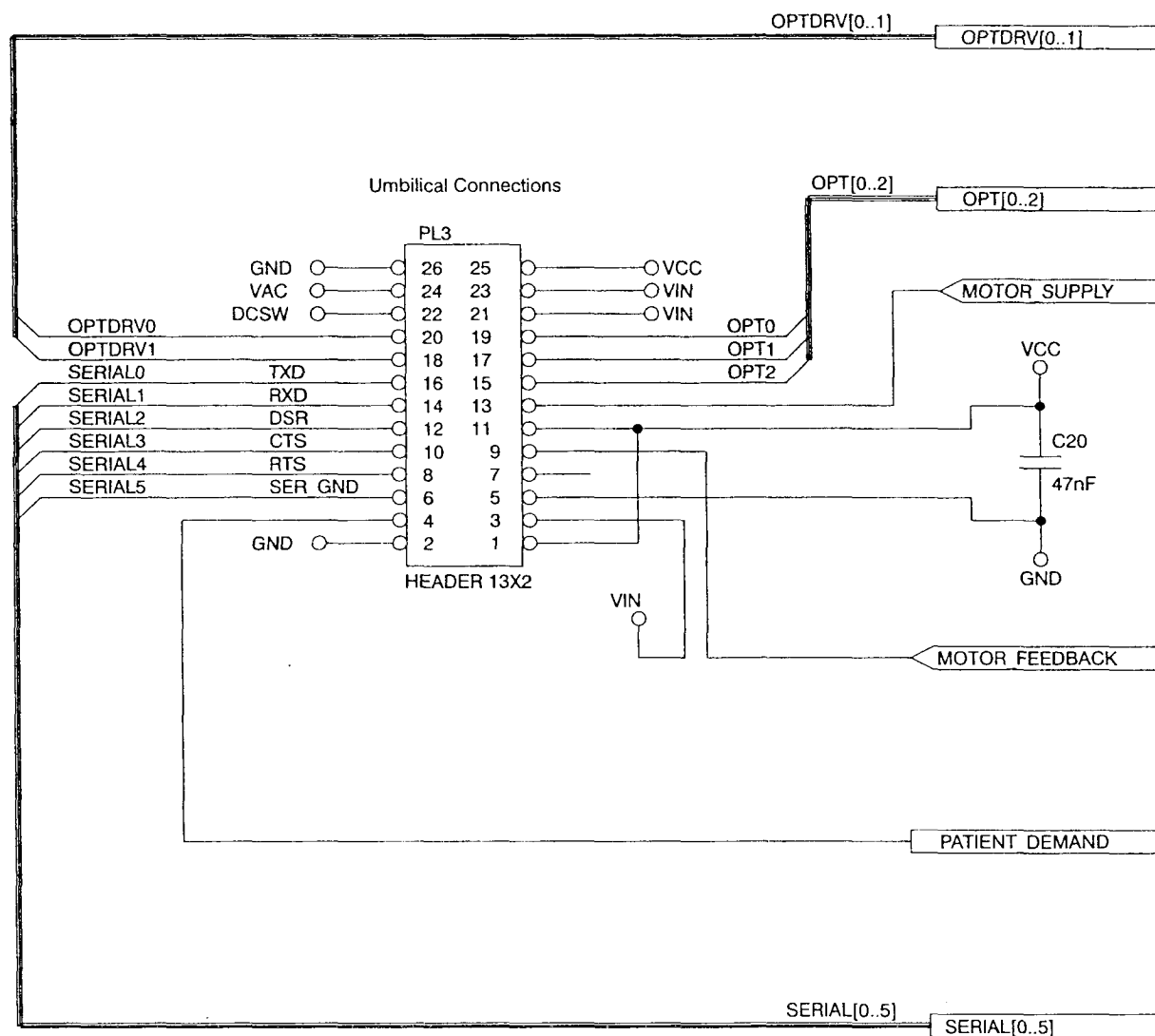


Figure 4-9 Main board input/output interface circuit diagram

Umbilical cable connections



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Figure 4-10 Umbilical cable connections diagram

Distribution board connections

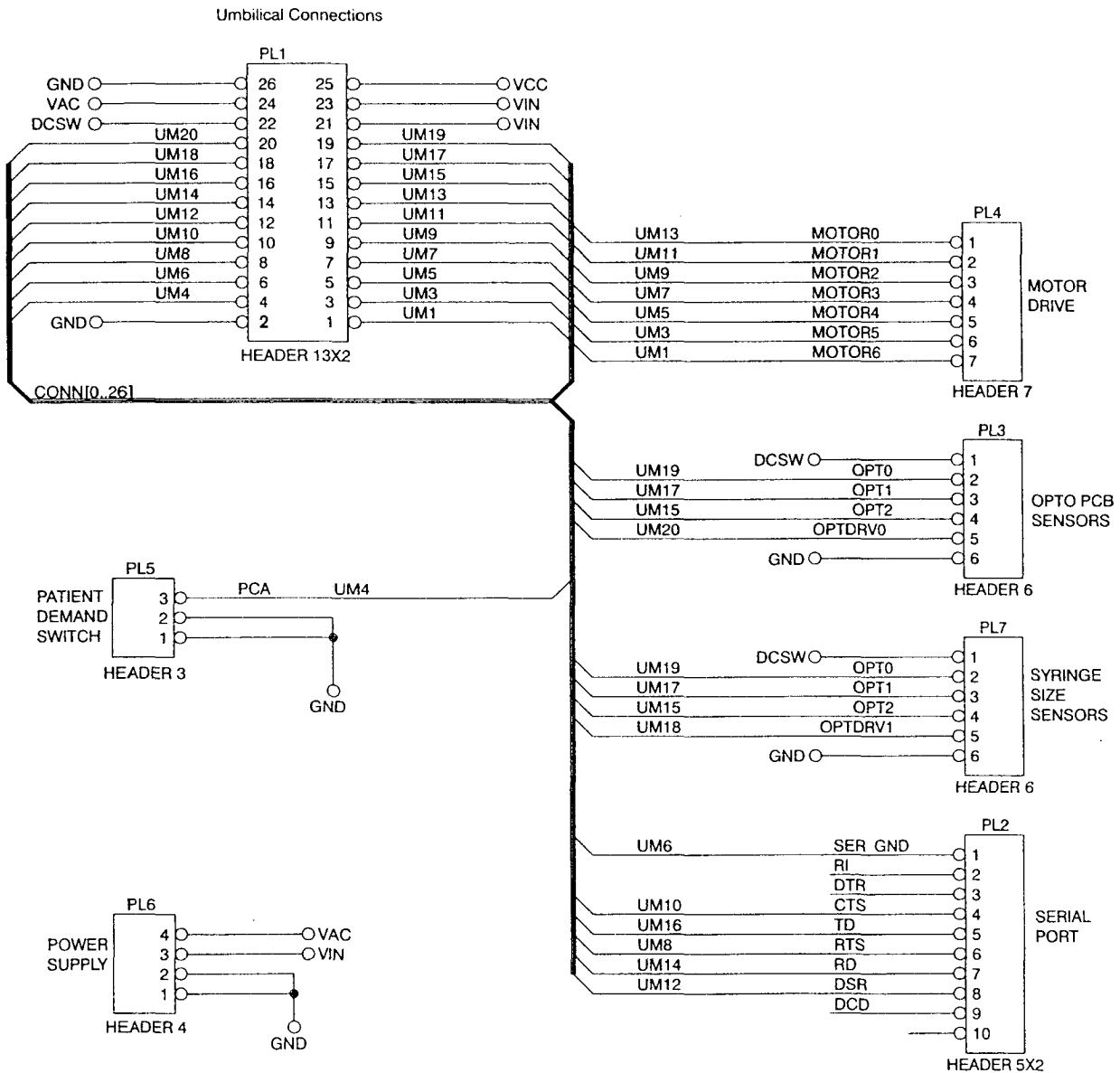


Figure 4-11 Distribution board connections diagram

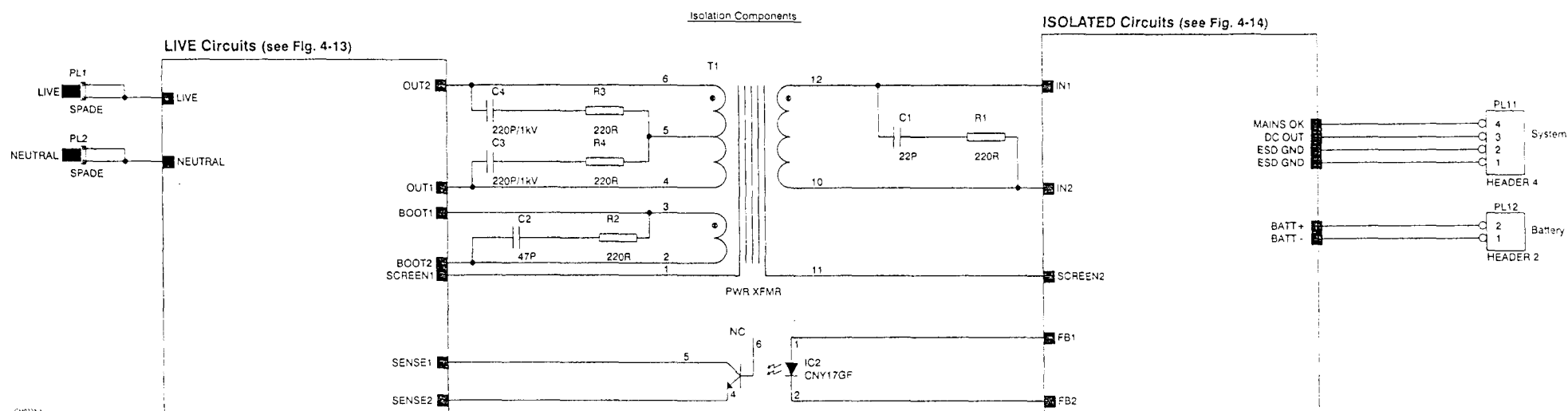


Figure 4-12 Regulator circuit diagram (overview)

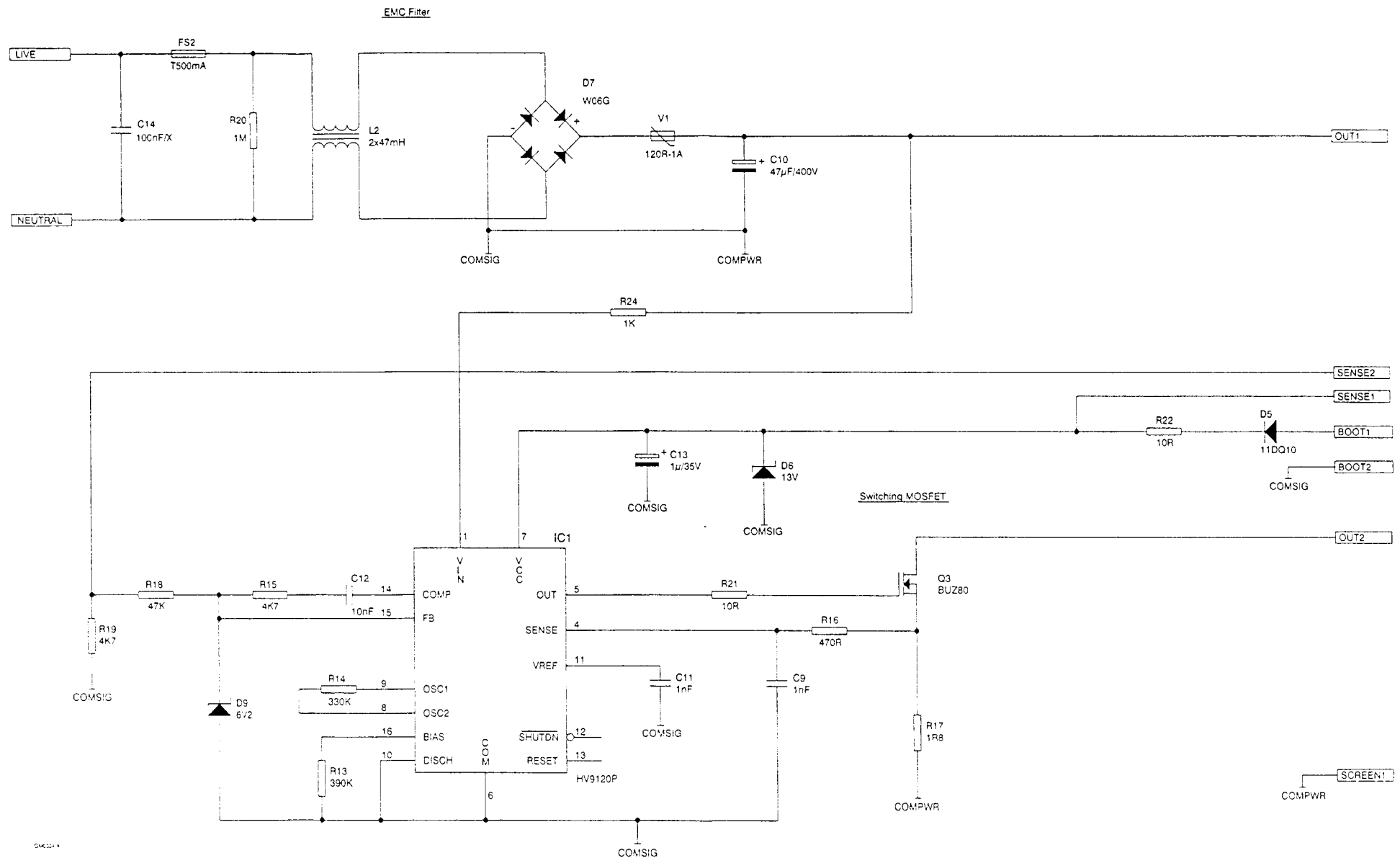


Figure 4-13 Regulator live circuit diagram

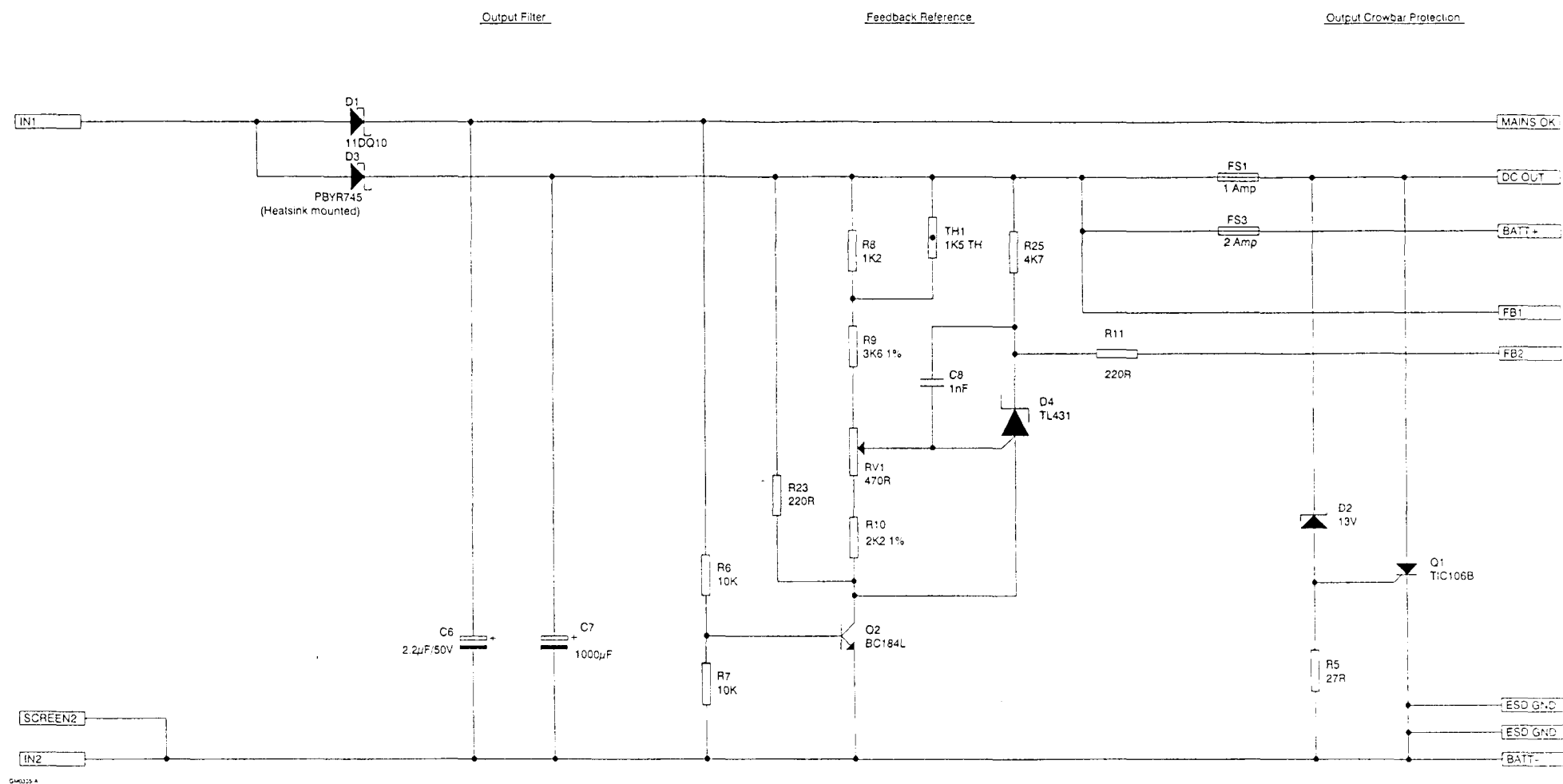
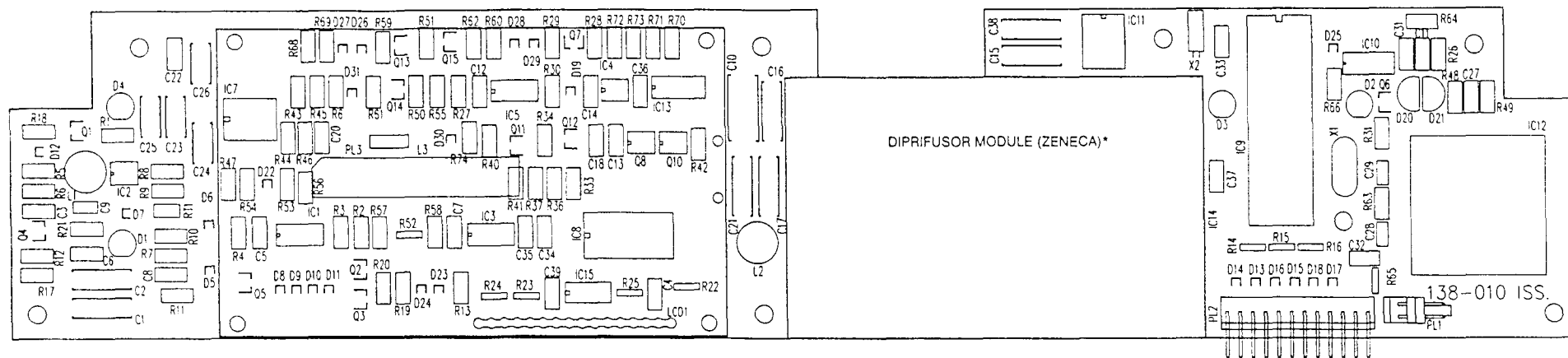


Figure 4-14 Regulator isolated circuit diagram



*NOTE:
Main Board with DIPRIFUSOR Module (as drawn) part no. 0138-0010
Main Board without DIPRIFUSOR Module part no. 0138-0028

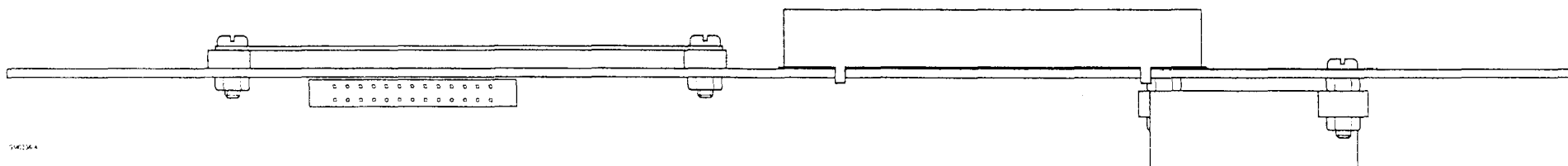
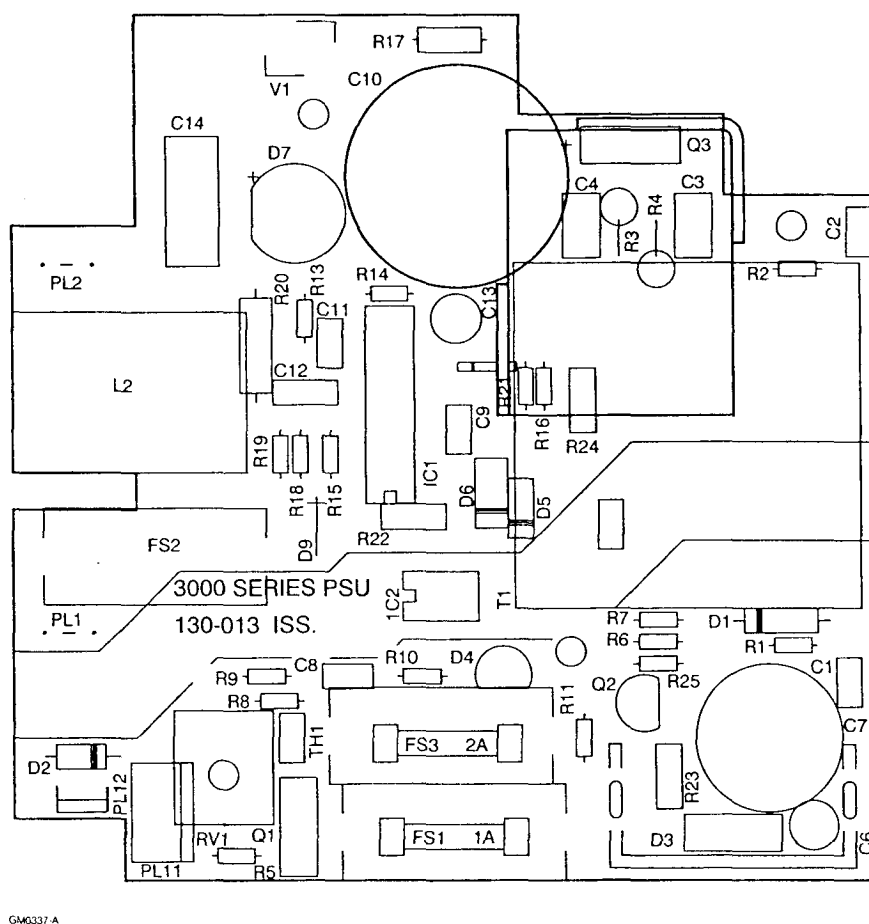


Figure 4-15 Main board: layout of components



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Figure 4-16 Regulator board: layout of components

Syringe size sensors board

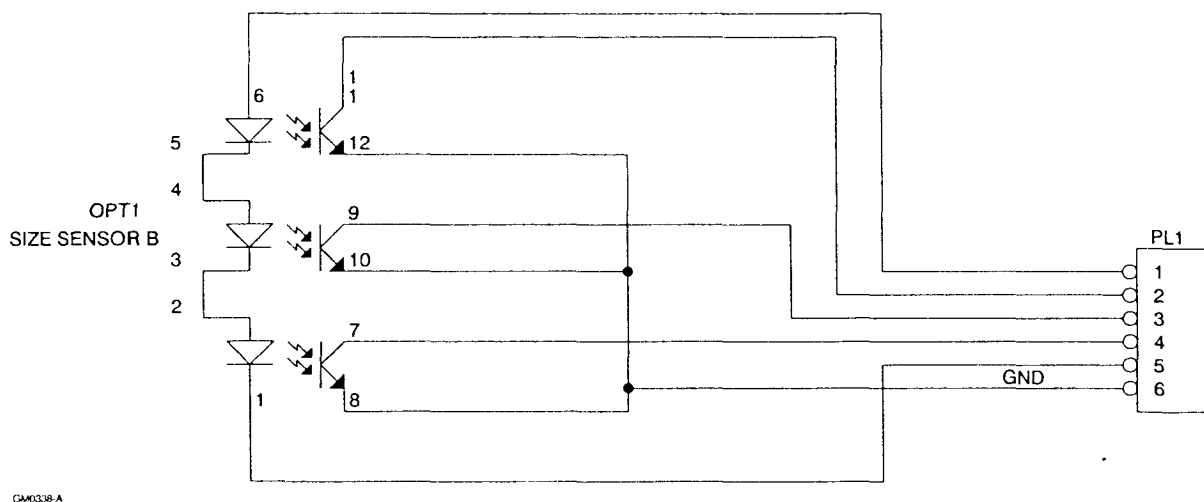


Figure 4-17 Syringe size sensors circuit diagram

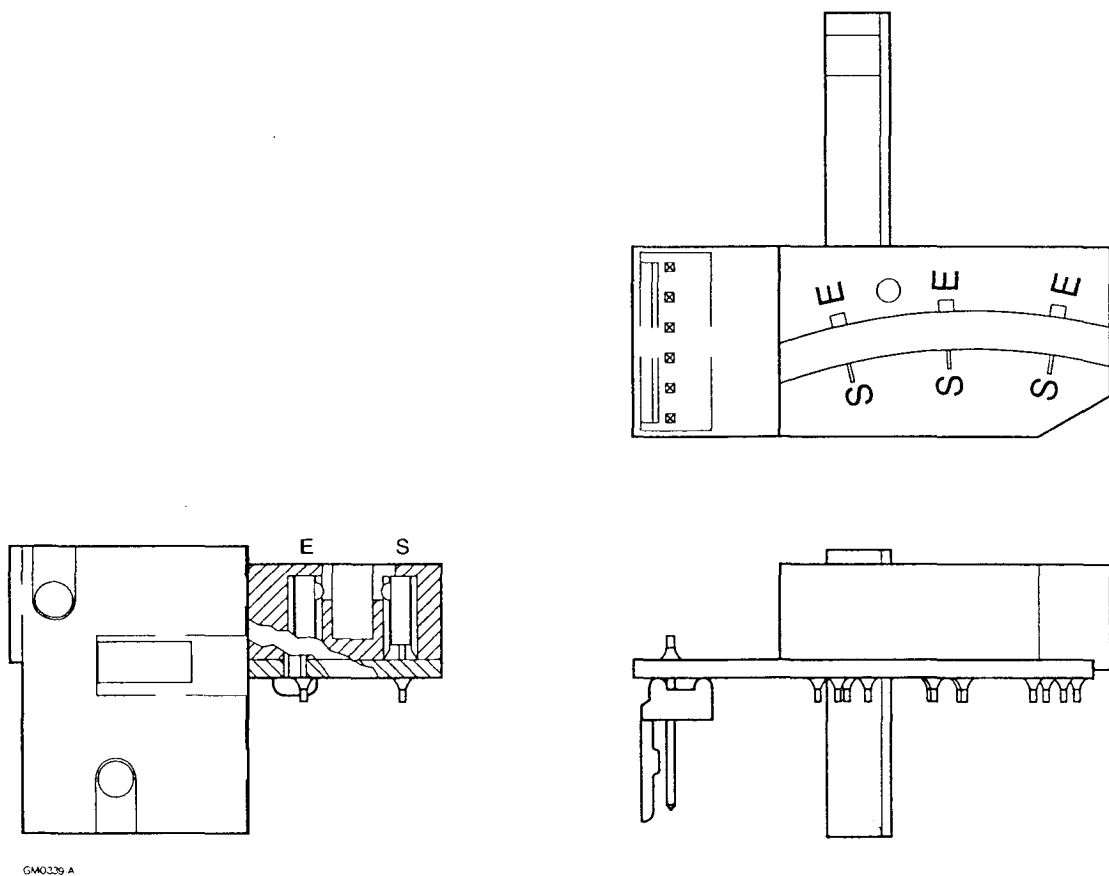


Figure 4-18 Syringe size sensors board: layout of components

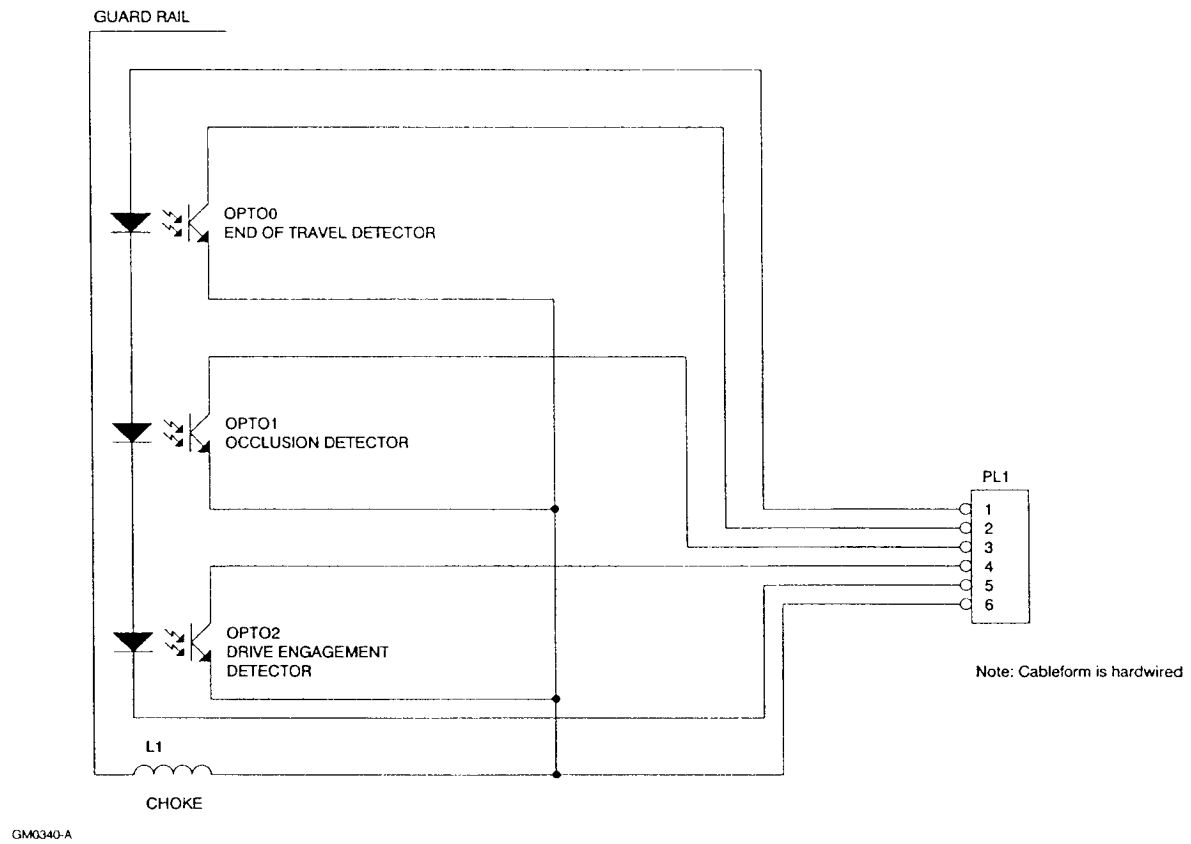


Figure 4-19 Opto sensors circuit diagram

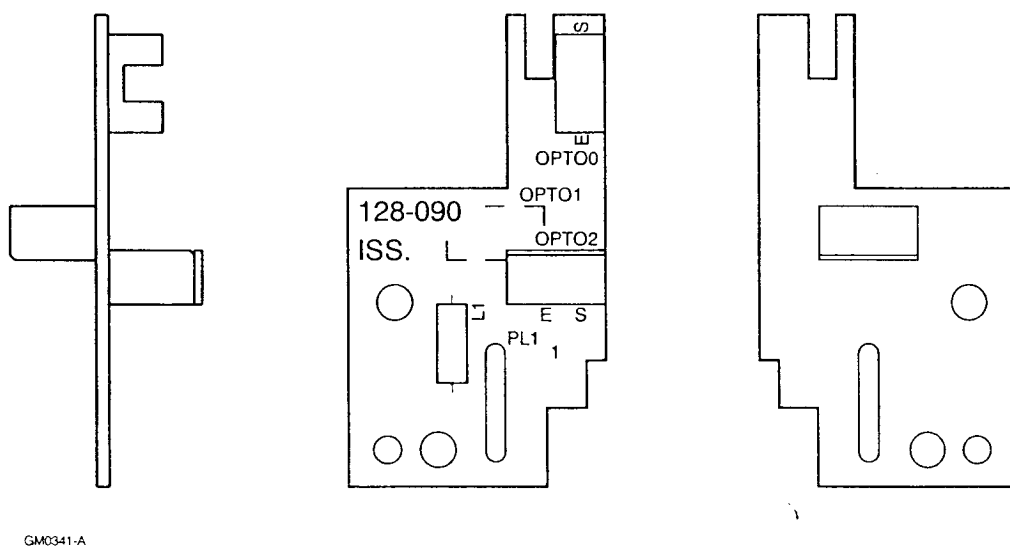


Figure 4-20 Opto sensors board: layout of components

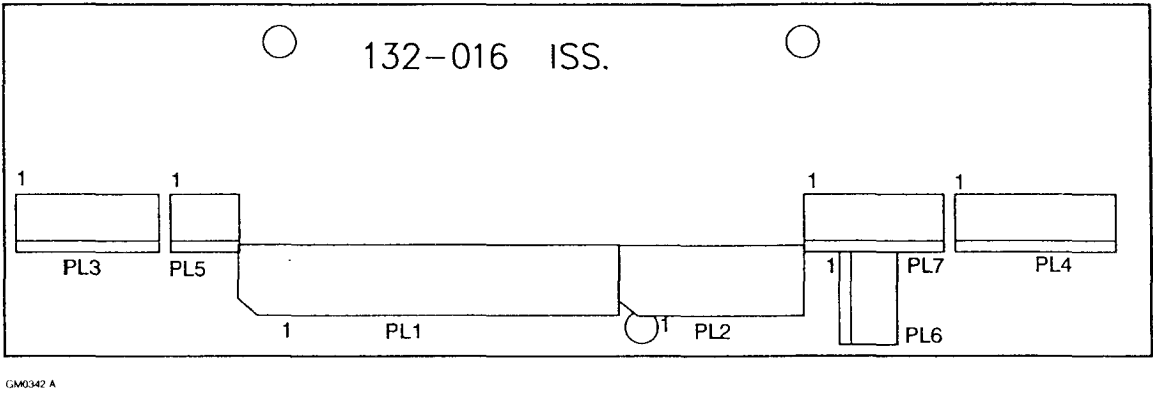


Figure 4-21 Distribution board: layout of components

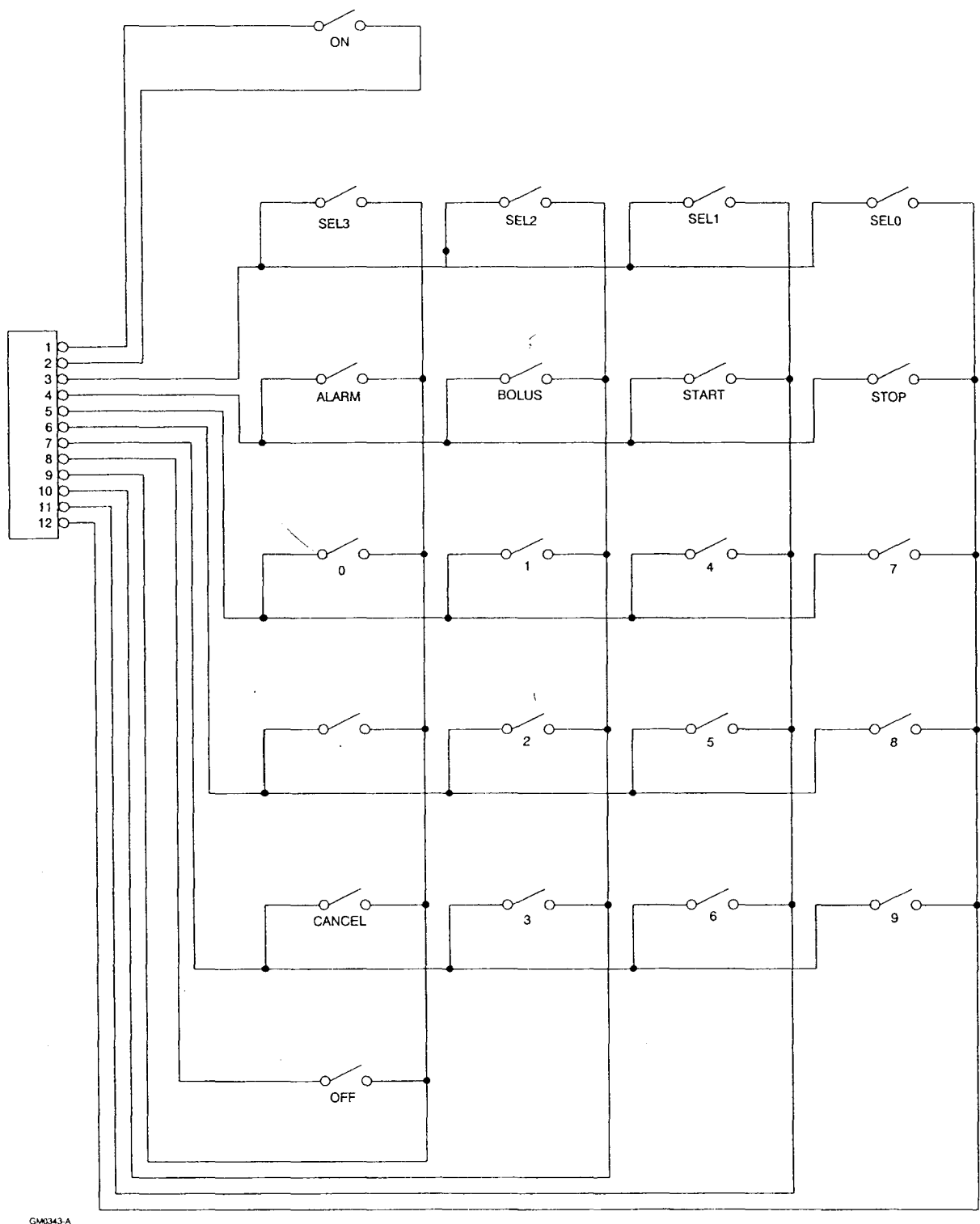
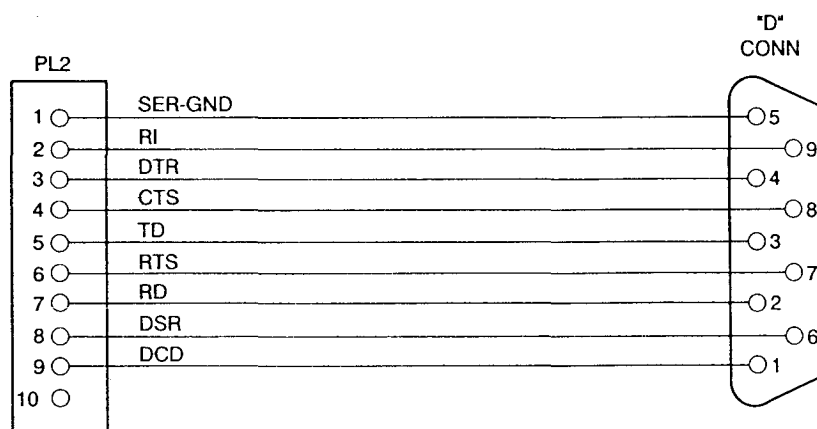


Figure 4-22 Membrane switch panel circuit

Internal ribbon cable



NOTE:

The RS232 Serial Interface connections to PL2 are shown on Fig. 4-11

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Figure 4-23 Internal ribbon cable and 'D' connector connections

CHAPTER 5

DIAGNOSTICS, CLEANING AND REPAIRS

Diagnostics

Comprehensive diagnostics have been designed into the 3500 so that should a fault occur it can easily be identified. The *Fault code* numbers that are allocated within the diagnostics are used to indicate the type of fault that has occurred.

The microprocessor is capable of recognising faults and generating *fault code* numbers in the range 0 to 97 (see Table 5-1). The *fault codes* are not expected to change for future software versions.

The normal operational ALARMS and WARNINGS are fully detailed in the 3500 Instruction Manual.

Table 5-1 Diagnostic fault codes

Code	Fault	Recommended action
07	RAM test failure	See item 2 on page 5-2
10	Motor fault	See item 4 on page 5-2
11	Watchdog interrupt	See item 2 on page 5-2
22	Unexpected interrupt	See item 2 on page 5-2
30	Unexpected program restart	See item 2 on page 5-2
34	Redundant variable mismatch	See item 2 on page 5-2
35	Variable out of range	See item 2 on page 5-2
38 and 39	Motor fault	See item 4 on page 5-2
45	Microprocessor fault	See item 2 on page 5-2
46	Internal watchdog fault	See item 2 on page 5-2
47	Program exception	See item 2 on page 5-2
51	Program exception	See item 2 on page 5-2
52	Program exception	See item 2 on page 5-2
55	Program exception	See item 2 on page 5-2
56	Internal register not correct	See item 2 on page 5-2
57 and 58	Calculation error	See item 2 on page 5-2
59	Program exception	See item 2 on page 5-2

(contd.)

Table 5-1 Diagnostic fault codes (contd.)

Code	Fault	Recommended action
61	Program exception	See item 2 on page 5-2
64	RS232 receiver overrun	See item 1 on page 5-2
66 and 67	Comms buffer overflow	See item 1 on page 5-2
68	RS232 buffer overflow	See item 1 on page 5-2
69	RS232 buffer overflow	See item 1 on page 5-2
70	CPU test failed	See item 2 on page 5-2
80 and 81	Watchdog test failed	See item 2 on page 5-2
82	Motor faulty	See item 2 on page 5-2
85	Power supply fault	See item 5 on page 5-2
87	CRC test failed	See item 2 on page 5-2
90	EEPROM failure	See item 6 on page 5-2
91	Keyboard fault	See item 3 on page 5-2
93,94,95	Diprifusor fault	See item 6 on page 5-2
96	ROM checksum fault also power on	See item 2 on page 5-2
97	Motor fault	See item 4 on page 5-2

The six items shown below (and cross referenced from Table 5.1) detail the possible cause of a fault, and the recommended action to be taken:

Item	Fault	Possible cause	Recommended action
1	Communication (Comms.) fault.	External interference... e.g. static interference or R.F. interference. Circuit fault.	Check communication link and interface cable. Return to Graseby.
2	Internal fault.	External interference... e.g. static interference or R.F. interference. Circuit fault.	Relocate the pump. Return to Graseby.
3	Keyboard fault.	Damaged keyboard.	Replace keyboard.
4	Motor fault.	Faulty motor or lead-screw drive assembly.	Check motor and lead-screw drive assembly.
5	Power supply.	Faulty power supply.	Check the power supply.
6	—	—	Return to Graseby.

Cleaning the pump

CAUTION

The 3500 must *not* be immersed in any liquids. Wipe off any liquid that may be spilt on the pump immediately.

The outer surfaces of the pump can be cleaned by wiping them over with a damp cloth (soapy if necessary).

Repair procedures

WARNINGS

The repair procedures detailed in the sections that follow this Warning, must only be carried out by qualified personnel.

Always disconnect the AC supply from the pump before opening the casing.

The safety and reliability of the pump may be compromised by the use of parts other than those specified in this Manual.

Introduction

In several of the repair procedures that follow, information has been given on how to remove and renew the whole of the particular assembly.

If a single component within an associated assembly is faulty and can be individually repaired, then reference to the appropriate illustrated parts exploded view will enable the single faulty component part to be renewed.

If a *leadscrew assembly* or a *half nut* is repaired within the pump, then both the following checks, and if necessary the associated adjustments must be carried out:

- Thrust checks (see page 2-9).
- Plunger clamp checks (see page 5-13).

Whenever the case is taken apart the *Syringe size sensors* tests detailed on page 6-2 must be carried out.

(contd.)

Fuse renewal

The pump contains three safety fuses.

These three fuses are all housed on the Regulator board and may be physically located with reference to Fig. 4-16.

Details of these fuses are as follows:

- *FS1* is a fuse located in the *isolated* DC line, and has a 1 A rating.
- *FS2* is an AC supply *time delay* fuse, and has a rating of 500 mA.
- *FS3* is a fuse located in the battery supply line and has a 2 A rating.

In order to renew a blown fuse the pump casing must be disassembled as detailed on page 2-7, this action will allow access to all three fuses. A blown fuse must only be replaced by a new fuse of the correct rating.

FS2 can be renewed by pulling off and retaining the fuse protective cover, and then prising out the blown fuse. Fit the new fuse and replace the protective cover.

FS1 or *FS3* can be renewed by removing and retaining the three pan head fixing screws and insulator in order to displace the board.

After replacing *FS1* or *FS3* refit the Regulator board.

Reassemble the pump casing as detailed on page 2-7.

Regulator board renewal

The Regulator board is mounted on the rear casing. It is held in place by three pan head self tapping screws.

1. Open the casing as detailed on page 2-7.
 2. Disconnect the two spade tags and the two cable connectors, PL11 and PL12.
 3. Remove and retain the three screws that hold the board in place, also retain the insulating card.
 4. Remove the faulty Regulator board.
 5. Fit a new Regulator board by reversing steps 2 and 3 detailed above, and then close the casing as detailed on page 2-7.
-

Main board renewal

The Main board is mounted on the front casing. It is held in place by six pan head self tapping screws.

1. Open the casing, as detailed on page 2-7.
2. Disconnect PL3, the umbilical ribbon cable, by exerting a firm pressure and sliding the connector towards the batteries.
3. Remove and retain the six fixing screws.
4. Remove and retain the small bracket (plus insulator) that keeps the aerial* and magnet in place.

*** Note:**

Observe how the 'U' aerial magnet is positioned in its concaved recess before removing the board.

5. Lift up the board and disconnect PL1 and PL2, thus allowing the faulty Main board to be removed.
 6. Fit a new board by reversing steps 2 to 5 detailed above, and then close the casing as detailed on page 2-7.
-

Displacement of the Distribution board tray

The Distribution board tray is situated on the rear casing above the leadscrew assembly. To obtain access to the various components that are situated underneath the tray, the tray will have to be displaced.

1. Open the casing, as detailed on page 2-7.
 2. Remove and retain the screw that is situated at the bottom and middle of the tray, this will allow the tray to be lifted up a small distance, being restricted by the ribbon cables.
 3. Once the required access has been obtained and the repair carried out the tray can be refitted by replacing the fixing screw, and the casing closed as detailed on page 2-7.
-

Distribution board renewal

The Distribution board is situated on the rear casing and is attached to the tray by three pan head self tapping screws.

1. Open the casing, as detailed on page 2-7.
 2. From left to right, remove PL1, PL2, PL6, PL4 and PL7 from the front of the board.
 3. Remove and retain the three screws from the front of the Distribution board, and then lift up the board.
 4. Disconnect PL3 and remove the faulty board.
 5. Fit a new board by reversing steps 2 to 4 detailed above, and then close the casing as detailed on page 2-7.
-

Opto sensors board renewal

The Opto sensors board (see Fig. 4-19 and 4-20) is mounted on the rear casing, to the left of the leadscrew (see Fig. 7-1). In order to remove the Opto board, both the Distribution board and PL3 on the Distribution board, will have to be removed.

1. Open the casing, as detailed on page 2-7.
 2. Remove the Distribution board and then disconnect PL3, as detailed on page 5-6.
 3. Displace the tray as detailed on page 5-6.
 4. Remove and retain the screw that is situated just below the Opto board, and holds the plastic cable holder in place.
 5. Remove and retain the two screws and washers that hold the Opto board in place.
 6. Ease out the plastic flag from the sensor, as the faulty board is lifted out. Be careful not to damage the occlusion disc that is situated underneath the opto board.
 7. Fit a new Opto board by reversing steps 2 to 6 detailed above, and then close the casing as detailed on page 2-7.
-

Plunger clamp and half nut assembly renewal

This assembly (Fig. 7-2) is held in place by a narrow spring, a circular guide tube and two clamp brackets that retain the square lay shaft. Page 5-11 details the procedures for renewing just the half nut.

1. Open the casing, as detailed on page 2-7.
 2. Displace the Distribution board tray (see page 5-6).
 3. Unhook the top of the retaining spring from the syringe size sensor lever arm.
 4. Remove and retain the three screws from the two clamp brackets that hold the square lay shaft in place (see Fig. 7-1 and 7-2). Remove and retain the two brackets.
 5. Carefully easing out the flag from its housing, lift up the square lay shaft and toggle mechanism.
 6. Lift the two guide tubes off their respective seating, then remove the plunger clamp; half nut and lay shaft assembly.
 7. Fit the new assembly by reversing the steps 2 to 6 detailed above, and then close the casing as detailed on page 2-7.
 8. Carry out the thrust and plunger clamp checks/adjustments as detailed on page 2-9 and 5-13 respectively.
-

Pole clamp renewal

1. Remove and retain the two screws that are inserted through the securing plate into the base of the pump (see Fig. 7-3).
 2. Remove the faulty pole clamp assembly.
 3. Fit the new assembly by replacing and tightening the two screws through the securing plate into the base of the pump.
-

Leadscrew assembly renewal

The leadscrew assembly (see Fig. 7-4) is held in the rear casing by two bearing clamp plates, and is also held under moveable tension by a strong spring. The occlusion pressure is set by adjusting the tension of the spring.

A plastic coupling bush on the right hand side of the leadscrew is key-way fitted on its right hand side which enables it to be coupled to the gear box. The other side of the coupling screws into the leadscrew with a left-hand thread, this threading prevents the motor from unscrewing the leadscrew coupling.

Removal

1. Open the pump casing as detailed on page 2-7.
2. Displace the Distribution board tray (see page 5-6).
3. Displace the Regulator board by removing and retaining the three pan head screws and the top insulating board. This displacement will assist in the following procedures.
4. Remove and retain the two pan head screws that hold the Sensor moulding assembly and the square lay shaft in place.
5. Place the plunger clamp almost to the end of its left hand travel.
6. Remove and retain the two pan head self tapping screws that hold the right hand plastic clamp bracket in place; remove and retain the bracket.
7. Raising up the syringe size sensor lever, and noting the separate case grooves that the leadscrew bearing and the gear-box fit in to, lift out the faulty leadscrew assembly, together with the motor and gear box.
8. The motor and gearbox are coupled to the right hand end of the leadscrew assembly. Uncouple the leadscrew assembly from the gearbox by pulling it away from the gearbox shaft.

(contd.)

Renewal

9. Fit a new leadscrew assembly by reversing steps 2 to 8 detailed above. During the fitting of the new leadscrew the spring pressure will have to be released (see below) in order to move the leadscrew assembly to the left, so that it fits correctly into the grooves of the rear casing.
10. Ensure that the groove on the syringe size sensor collar (through which the larger telescopic tube slides) fits correctly into the concaved rear casing.

Releasing the spring pressure

11. If necessary, rotate the leadscrew so that the small grub screw that is situated in the grooved occlusion nut, on the right hand side of the leadscrew, is accessible. Using a 1.5 mm hexagon key loosen the grub screw.
12. Ensuring that the leadscrew does not turn, move the occlusion nut counter-clockwise (i.e. towards the left of the leadscrew) in order to relax the spring tension.
13. When the leadscrew assembly has been correctly positioned tighten the grub screw.

Case assembly and checks

14. Assemble the casing as detailed on page 2-7.
 15. Carry out the thrust and plunger clamp checks/adjustments as detailed on page 2-9 and 5-13 respectively.
-

Motor and gearbox assembly renewal

1. Open the casing, as detailed on page 2-7.
 2. Remove the motor connector (PL4) from the Distribution board, and then displace the Distribution tray by removing and retaining the bottom pan head screw.
 3. Remove the leadscrew assembly together with the gearbox and motor, as detailed on page 5-8.
 4. Remove the faulty motor and gearbox assembly by pulling it away from the leadscrew assembly.
 5. Fit the new motor and gearbox assembly by reversing steps 2 to 4 detailed above, and then close the casing as detailed on page 2-7.
-

Occlusion clutch and disc assembly renewal

The occlusion clutch and disc assembly (see Fig. 7-1) are situated on the left hand side of the leadscrew assembly, underneath the opto sensors board. The leadscrew assembly has to be removed in order to renew the clutch and disc.

1. Open the pump casing as detailed on page 2-7.
 2. Remove the Opto sensors board as detailed on page 5-7.
 3. Remove the leadscrew assembly as detailed on page 5-8, complete with the motor and gearbox.
 4. Remove and retain the two screws and the bracket that holds the clutch and disc assembly in place.
 5. Remove the faulty clutch and disc assembly.
 6. Fit a new clutch and disc assembly by reversing steps 2 to 4 detailed above, and then assemble the casing as detailed on page 2-7.
 7. Adjust the occlusion thrust as detailed on page 2-9.
 8. Check and adjust if necessary, the plunger clamp closed position as detailed on page 5-13.
-

Membrane switch panel renewal

The Membrane switch panel has an adhesive backing that enables it to be fixed to the top of the front casing. Do *not* bend the new Membrane switch panel or its flexible cable loom.

1. Open the pump casing as detailed on page 2-7.
2. Displace the Main board by removing and retaining the six pan head fixing screws. Disconnect the switch panel ribbon cable connector PL2 from the right hand underside of the Main board (this is a non-locking connector).
3. Starting by lifting a corner, peel the faulty switch panel away from the case. Pull the loose connector out through the front casing slot, and remove the faulty switch panel.
4. Remove traces of old adhesive from the front case recess (a cloth lightly dampened with white spirit may be used).
5. From the top of the new switch panel peel back the protective paper backing as far as the top of the display window.

(contd.)

**Membrane
switch panel
renewal** (contd.)

6. Push the connector and flexible lead of the new switch panel through the slot in the case.
 7. Align the top edge and sides of the panel with the top and sides of the case recess. Gently rub the top edge of the switch panel to adhere it lightly to the case and then remove the remainder of the protective backing paper.
 8. Working from the top downwards and using light pressure lay the panel into the case recess.
 9. When the switch panel is positioned correctly into the case recess (i.e. no over-hanging edges), use a *soft* cloth to rub the panel down firmly, pushing out any air bubbles at the same time.
 10. Connect the flexible lead to PL2 (Main board), and using the six screws that were previously removed, refit the Main board to the top half of the casing.
 11. Assemble the casing as detailed on page 2-7.
-

**Half nut
renewal**

The half nut casting (see Fig. 7-2) is clamped onto the left hand end of the outer metal tube by an M4 countersunk screw that is tightened into a recess positioned hexagonal nut. It is also attached to the toggle mechanism by a *Spirol* connecting pin.

1. Open the pump casing as detailed on page 2-7.
2. Remove and retain the *Spirol* connecting pin that fixes the half nut to the toggle mechanism.
3. Unhook the top of the retaining spring (2 mm dia. by 2.5 cm long) from the syringe size sensor lever arm.
4. Lift the two guide tubes off their respective seating, and then remove the attached assembly complete with the faulty half nut from the pump.
5. Remove and retain the half nut countersunk clamping screw and associated nut.

(Contd.)

Repair procedures

Half nut renewal (contd.)

6. Lever the sides of the half nut apart in order to disengage the casting pip from the locating hole in the guide tube.
 7. Fit a new half nut by reversing steps 2 to 6 detailed above, ensuring that the casting pip is placed in the locating hole.
 8. Close the casing as detailed on page 2-7.
 9. Carry out the thrust and plunger clamp checks/adjustments as detailed on page 2-9 and 5-13 respectively.
-

Syringe size sensor board renewal

The syringe size Sensor board (see Fig. 4-17 and 4-18) and its moulding are fixed adjacent to the motor, at the right hand end of the leadscrew assembly (see Fig. 7-1).

The moulding is fixed in place by two pan head self tapping screws. The board is fixed to the moulding by a single self tapping screw.

1. Open the casing as detailed on page 2-7.
 2. Remove the connector PL1 from the Sensor board.
 3. Remove and retain the two moulding pan head fixing screws.
 4. Lift out the Sensor moulding and its shim, and also the attached board.
 5. Remove and retain the fixing screw situated between the board and the moulding.
 6. Carefully prise the board away from its moulding. A small amount of resistance may be experienced when prising the three extending opto sensors (that are fixed to the board) away from the moulding.
 7. Fit a new sensor board by reversing steps 2 to 6 detailed above, and then close the casing as detailed on page 2-7.
 8. Carry out the syringe size sensors tests as detailed on page 6-2. If necessary select the shim on the bottom of the moulding in order to obtain the correct results. The thickness of the shims available are 0.6, 0.8 and 1.0 mm.
-

Plunger clamp checks/adjustments

When the plunger clamp is closed (i.e. moved forward) the set distance from the clamp to the front case is important and can be checked and if necessary adjusted.

Also, the distance that the clamp is *initially* allowed to move from this set position before the *half nut* disengages and an alarm operates can be checked, and if necessary adjusted, as described in the procedures that follow.

The plunger clamp *set* and *initial* openings must be checked and/or adjusted whenever a new *leadscrew* or *half nut* is fitted.

These checks/adjustments must be carried out for the following two reasons:

- *Set* check: to allow insertion of all the syringe brands named in the specification (see page 1-5).
- *Initial* check: so that the **CLAMP OPEN** alarm is generated *before* the half nut slips.

8 mm to 10mm check

1. Insert a 50/60 ml syringe and run *purge* for 10 seconds to ensure that the half nut is fully engaged in the leadscrew.
2. Measure the distance from the forward edge of the plunger clamp to the front case moulding. Record this measurement, which must be between 8 mm and 10 mm.

Adjustment

3. If the required *set* opening distance cannot be achieved, the AC power must be switched off; the case opened (see page 2-7) and the half nut clamping screw loosened so that the position of the half nut relative to the outer tube can be adjusted.
4. Tighten the clamping screw, assemble the case and repeat the procedures given in 1 and 2.

Alarm check

1. Insert a dummy syringe and start an infusion. This will ensure that the half nut is fully engaged in the leadscrew.
2. Slowly *open* the plunger clamp until the **CLAMP OPEN** alarm operates, checking all the time whilst carrying out this *opening* movement, that the plunger clamp does not slip on the leadscrew, this is achieved by applying a firm side-ways hand pressure to the plunger clamp.
3. It is essential that the **CLAMP OPEN** alarm operates before the half nut begins to slip on the leadscrew.

(contd.)

Repair procedures

Adjustment

4. It is also important that the alarm must not operate until the plunger clamp has been *opened* by approximately a further 2 mm from the set opened measurement recorded in paragraph 2 in the above section. This plunger clamp *initial* movement prevents an oversensitive response should the plunger clamp be jolted for any reason.
 5. If the above *initial* opening distance cannot be achieved, the AC power must be switched off; the case opened (see page 2-7) and the two screws on the Opto sensors board (see Fig. 7-1) loosened to enable the board position to be adjusted. Moving the opto sensors board away from the back of the case will reduce the *initial* measurement distance, i.e. make the alarm more sensitive.
 6. Tighten the sensors board fixing screws (2 off), close the case (page 2-7) and repeat the procedures given in 1 to 4 above.
-

Plunger clamp repair

The plunger clamp cover must be removed in order to reach the internally located lock or pin moulding (see Fig. 7-2). The outer casing of the clamp is fixed to the right hand end of the outer tube.

1. Remove and retain the two screws that hold the plunger clamp cover onto the outer casing, and remove the cover.
 2. The lock and pin moulding together with the associated spring will become accessible
 3. As required, fit a new lock and/or pin, then assemble the clamp as detailed in 1 above.
-

Renewal of batteries

The rechargeable batteries are held in place in the front casing by three-pronged flexible plastic mouldings (see Fig. 7-1). The batteries will normally last indefinitely, but if they should fail to charge then they must be replaced .

1. Open the casing as detailed on page 2-7.
 2. Noting their orientation, prise out the three faulty batteries.
 3. Noting the polarity of the connections remove all six spade tags.
 4. Reconnect three fully charged 2 V, 2.5 AH, lead acid, D Cell batteries by reversing the steps detailed in 2 and 3 above.
 5. Close the casing as detailed on page 2-7.
-

CHAPTER 6

FUNCTIONAL TESTS

Introduction

Carry out the following tests (Table 6-1) before putting the pump into service for the first time, and as required. The following functional tests have been designed to verify that the pump is safe to use.

It has been assumed that the Technician who will be carrying out the functional tests, is familiar with the operation of the pump as detailed in the 3500 Instruction Manual.

If any one of the pumps functional tests fail and you are unable to rectify the fault yourself, then contact either your local representative or Graseby Medical (Customer Care).

Table 6-1 Functional tests

Step	Test	Method	Correct result
1	Mechanical inspection.	Before applying AC power to the pump, check that the case and exposed mechanical parts are free from any damage.	No visible damage.
2	Electrical safety test.	Using a test voltage of 500 V DC, measure the insulation resistance between the AC inlet and the exposed metal parts.	The insulation resistance must be greater than 200 Meg ohm.
3	Initial power ON .	Connect the AC supply. Press the ON button.	The LED lights. All four LEDs are briefly illuminated; the sounder activates, and the STOP and LEDs remain on. If a syringe is fitted, the syringe type; size and the last infusion rate will then be displayed.

(contd.)

Functional tests

Table 6-1 Functional tests (contd.)

Step	Test	Method	Correct result
4	Syringe size sensors.	Set the plunger clamp to its mid position. Insert (consecutively) the following diameter rods in the pumps syringe trough: 11.2 mm diameter. 12.5 and 15 mm dia. 16.2 and 18.2 mm dia. 21.0 and 23.0 mm dia. 23.7 and 26.8 mm dia. 29.0 to 33.1 mm dia.	SYRINGE INVALID displayed. 5 ml syringe displayed. 10 ml syringe displayed. 20 ml syringe displayed. 30 ml syringe displayed. 60 ml syringe displayed.
5	Membrane buttons and display. ON/OFF buttons. Numeric buttons.	With the pump ON, press the OFF button. Press the ON button. Press the four following sets of numeric buttons, and press the CANCEL button after each sequence: 1. Full stop (.) then 9. 2. 1; 2 and 3. 3. 4; 5 and 6. 4. 7; 8 and 9.	The display goes blank, but the LED remains lit. As in Step 3 (Initial power ON). Check that the rate display shows the following: 0.9 ml/h then 0.0 ml/h. 123 ml/h then 0.0 ml/h. 456 ml/h then 0.0 ml/h. 789 ml/h then 0.0 ml/h.

(contd.)

Table 6-1 Functional tests (contd.)

Step	Test	Method	Correct result
5 (contd.)	Totalizer.	Check that the totalizer buttons operate correctly (see Instruction Manual).	Display shows volume infused since last reset, then resets to zero when the reset button is pressed.
	Infusion.	Fit a syringe and move the plunger clamp to the <i>closed</i> (forward) position. Press the START button.	The syringe type and size is briefly displayed; the infusion starts with the START LED flashing, and the <i>running</i> indication arrows on the display also flashing.
	Bolus.	Check that the bolus facility operates correctly (see Instruction Manual).	Alarm and start lamps flash and the display shows the bolus delivered.
	Infusion rate.	Check that the infusion rate can be changed (see Instruction Manual). Press STOP .	The displayed rate of infusion changes. The pump changes to its set-up mode.
	Clamp alarm.	Press START and then move the plunger clamp to its open (up) position. Press the ALARM button.	The alarm sounds, the red ALARM LED flashes and CLAMP OPEN is displayed. The alarm is silenced and the pump goes into its set-up mode.
6	AC power failure.	With a syringe inserted press the START button to start an infusion, then switch off the AC supply externally.	The alarm sounds intermittently; MAINS FAIL is displayed (also intermittently) and the pump continues running under battery power.
		Switch on the AC supply.	The lamp lights.

(contd.)

Table 6-1 Functional tests (contd.)

Step	Test	Method	Correct result
7	Accuracy of infusion. Use a new syringe to prevent a false result.	Using a new 60 ml BD syringe, close the plunger clamp in (approx.) mid position and run purge in order to remove any backlash. Then set the rate at 400 ml/h and run an infusion for exactly 90 seconds.	Check that the plunger clamp has moved a distance of between 17.8 and 18.4 mm during the 90 seconds infusion time.
8	Occlusion.	The occlusion thrust is factory set by applying an opposing force to the plunger clamp. This is achieved by using weights.	With the pump positioned vertically, a 5.7 and a 6.2 kg weight is required (page 2-9 refers).
9	Clamp open.	Insert a BD 50 ml syringe and start an infusion. Slowly open the plunger clamp, checking all the time whilst carrying out this opening movement the plunger clamp does not slip on the leadscrew (see page 5-13).	The CLAMP OPENED alarm and message must operate before the plunger clamp slips on the leadscrew.
10	Syringe display... NEARLY EMPTY EMPTY/OCCLUSION alarms.	Using a BD 60 ml syringe, set the pump for a 200 ml infusion. Set the syringe to approx. 5 ml before the end of travel. Start an infusion and run to end of plunger travel.	Check that an intermittent double beep and an intermittent alarm message... NEARLY EMPTY occurs before the end of travel, and, at the end of travel a continuous alarm sounds and the message... EMPTY/OCCLUSION occurs and the pump stops.

(contd.)

Table 6-1 Functional tests (contd.)

Step	Test	Method	Correct result
11	Syringe display... < 3 mins to END ENDED (KVO = 0.5) alarms.	Using a BD 60 ml syringe, set the pump for a 100 ml/h infusion. Set the syringe plunger just greater than 15 ml before the end of travel. Start an infusion and run to end of plunger travel.	At about 7 ml before end of travel check that intermittent alarm sounds and the intermittent message... < 3 mins to END appears, and, at approx. 2 ml from the end a continuous alarm sounds and the following message appears... END (KVO = 0.5).
12	TCI.	In the configuration mode set the pump to... MODE = BOTH. Turn the pump OFF and then ON and select the TCI operational mode. Correctly load a tagged Zeneca PFS. Enter the three default parameters... TARGET = 4.0 µg/ml AGE = 40 years WEIGHT = 70 kg and press START to start a TCI infusion.	LOAD SYRINGE message appears. The first TCI parameter message is displayed (i.e. TARGET). Check that the pump delivers a bolus until the TARGET concentration is reached. Then allow the pump to infuse for at least a further 30 seconds.

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CHAPTER 7

ILLUSTRATED PARTS LISTS

Table 7-1 General assembly IPL

Item (Fig. 7-1)	Description	Part number	Remarks
—	GM 3500, Diprifusor model	0138-0001	UK
—	GM 3500, Non Diprifusor	0138-0716	Japanese
—	GM 3500, Non Diprifusor	0138-0720	UK
1	Plunger clamp/half nut assy	0132-0050	See Table 7-2
2	Pole clamp assembly	0131-0083	See Table 7-3
3	Motor and leadscrew assy.	—	See Table 7-4
4	Opto sensors board	0128-0090	See Table 7-5
5	Size sensors board	0130-0017	See Table 7-6
6a	Main board (plus TCI module)	0138-0010	See Table 7-7
6b	Main board (no TCI module)	0138-0028	See Table 7-7
7	Regulator board assembly	0130-0013	See Table 7-8
8	Distribution board	0132-0016	—
9	Distribution tray	0130-0020	—
10	Occlusion sensing assembly	0131-0067	Disc, body and clutch
11	Case front fabrication	0138-0018	—
12	Case rear moulding	0132-0006	Replace at service centre
13a	Membrane front panel label	0138-0027	TCI model
13b	Membrane front panel label	0138-0012	Non TCI model
14a	Rear panel label, UK	0132-0008	TCI model
14b	Rear panel label, Japan	0138-0031	Non TCI model
15	Plunger clamp flag moulding	0127-0019	—
16	Support tube	0127-0047	—
17	Plastic film member	0131-0081	—

Table 7-1 General assembly IPL (contd.)

Item (Fig. 7-1)	Description	Part number	Remarks
18	Syringe barrel clamp assy.	—	—
19	Pivot block moulding	0127-0031	—
20	Clamp finger	0132-0023	—
21	Torque spring	0132-0025	2 off
22	Insulation foam	0056-0772	—
23	Leadscrew bearing brkt. L.H.	0127-0051	—
24	Square shaft bracket L.H.	0127-0052	—
25	Leadscrew bearing brkt. R.H.	0132-0053	—
26	Standard nearly empty flag: Issue C, half nuts E and previous. Issue D, half nuts F and onwards.	0131-0046	Screw fitting. Barb fitting.
27	Rubber feet	0126-0028	2 off
28	PSU board shield	0130-0038	—
29	Cable clamp	0127-0043	—
30	Cable clamp customised	0131-0088	—
31	Cable assy. and D connector	0053-0657	—
32	Cable assembly, a.c. supply	0053-0646	Internal; 2-wire
33	Cable assembly, battery A	0053-0647	Not illustrated
34	Cable assembly, battery B	0053-0648	Not illustrated
35	Cable assembly, battery C	0053-0649	Not illustrated
36	Cable assembly, Umbilical to Main board	0053-0681	—
37	Cable assembly, Umbilical to Regulator board	0053-0680	—
38	Cable assy. size sensor	0053-0678	—

(contd.)

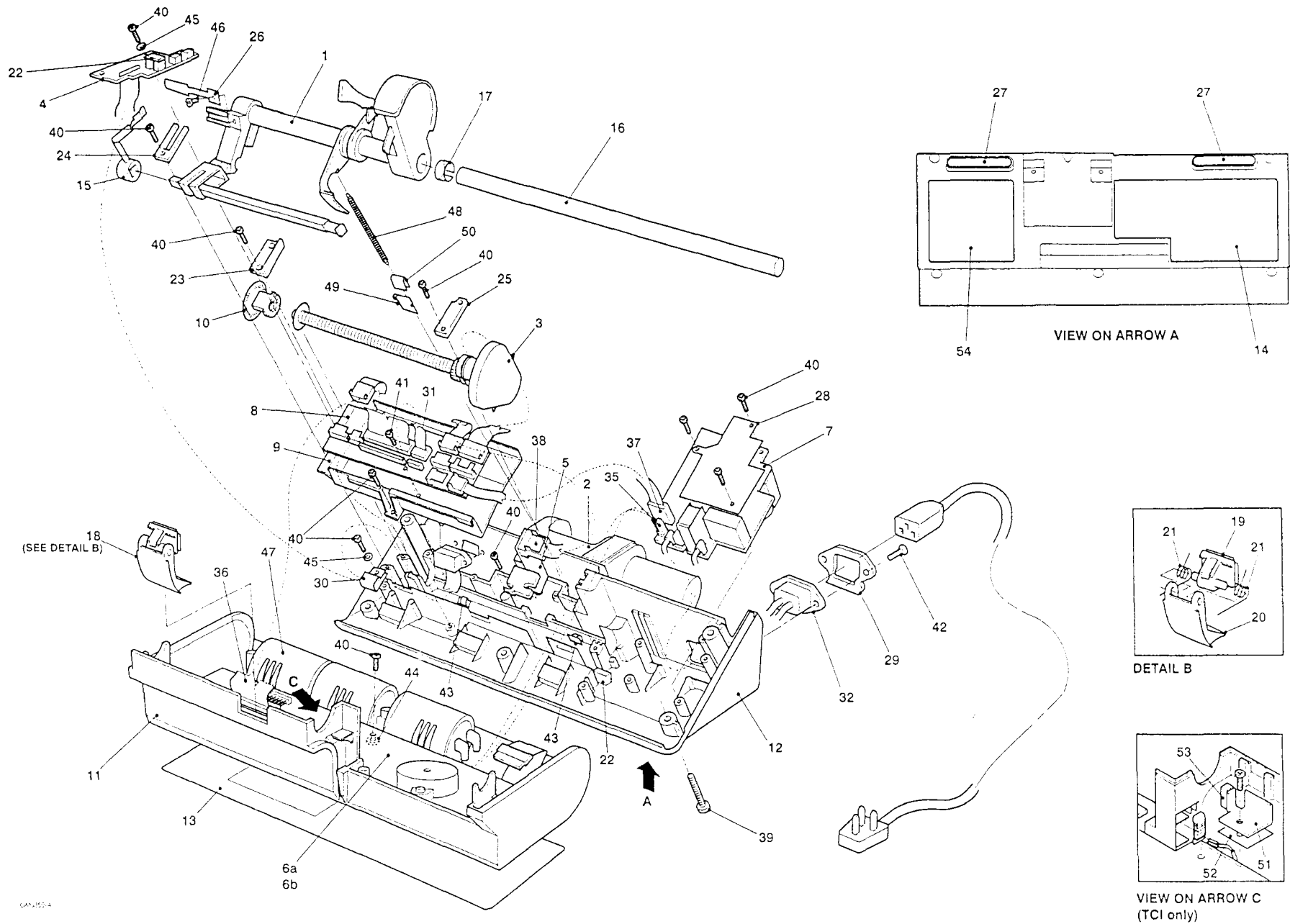


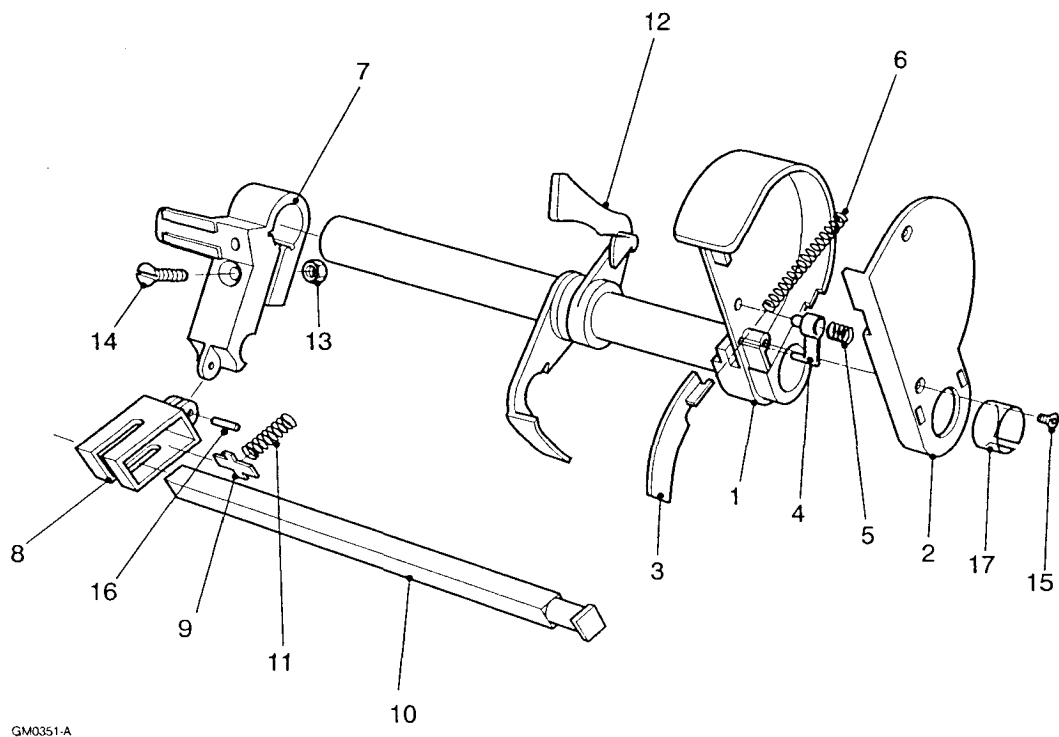
Figure 7-1 General assembly IP diagram

Table 7-1 General assembly IPL (contd.)

Item (Fig. 7-1)	Description	Part number	Remarks
39	Screw M4 x 20 pan head, slot	5001-0542	6 off
40	Screw M3 x 10 pan head, self tap, pozi	5017-9960	20 off
41	Screw M3 x 7 pan head, self tap, pozi	5017-9990	3 off
42	Screw M3 x 10 c'sk, self tap, pozi	5017-9962	2 off
43	Cable clamp	5366-2810	2 off
44	Washer anti-loss M3, skiffy	5014-0588	6 off
45	Washer 1/8 x 5/16 T3 heavy, BZP	5014-3020	3 off
46	Screw M2, 5 x 5 pan head, slot	5000-4642	—
47	Battery, 2 V, 2.5 AH Cyclon	3420-2120	3 off
48	Spring EIO14B7MW LEE	5752-0039	—
49	Size sensor anchor plate spring	0128-0048	—
50	Clip spire 11560-11	5050-0430	—
51	Aerial securing bracket	0138-0021	TCI only
52	Bracket shield	0138-0022	TCI only
53	Tesamoll, 12 x 16 mm blk	056-771	TCI only
54	Zeneca rear custom label, UK	0138-0013	TCI only
55a	AC power lead and connector	3700-0026	UK
55b	AC power lead and connector	3700-0025	Japan
56	Instruction manual, UK	0138-0016	Not illustrated
57	Technical Service Manual (TSM), UK	00SM-0138	Not illustrated
58	Insulation foam, 5046x19 mm	056-772	Not illustrated

Table 7-2 Plunger clamp and half nut assembly IPL

Item (Fig. 7-2)	Description	Part number	Remarks
—	Plunger clamp and half nut assy.	0132-0050	Fig. 7-1 and 7-2
1	Plunger clamp and tube	0127-0044	—
2	Plunger clamp cover	0127-0045	—
3	Plunger clamp lock	0127-0036	—
4	Plunger clamp pin	0127-0037	—
5	Plunger clamp conical spring	0127-0100	—
6	Plunger clamp finger spring	5752-0027	—
7	Half nut casting	0132-0042	—
8	Toggle moulding	0127-0026	—
9	Toggle glide moulding	0127-0027	—
10	Square shaft	0127-0048	—
11	Toggle spring LC-032C-7-MW	5752-0010	—
12	Size sensor flag moulding	0130-0025	—
13	Nut M4 full, hex	5011-0750	—
14	Screw M4 x 16 csk, slot	5065-4500	—
15	Screw M4 x 6 csk, pozi	5065-3160	—
16	Spirol pin 2 x 12 mm MDK	5028-2016	—
17	Plastic film member	0131-0081	—

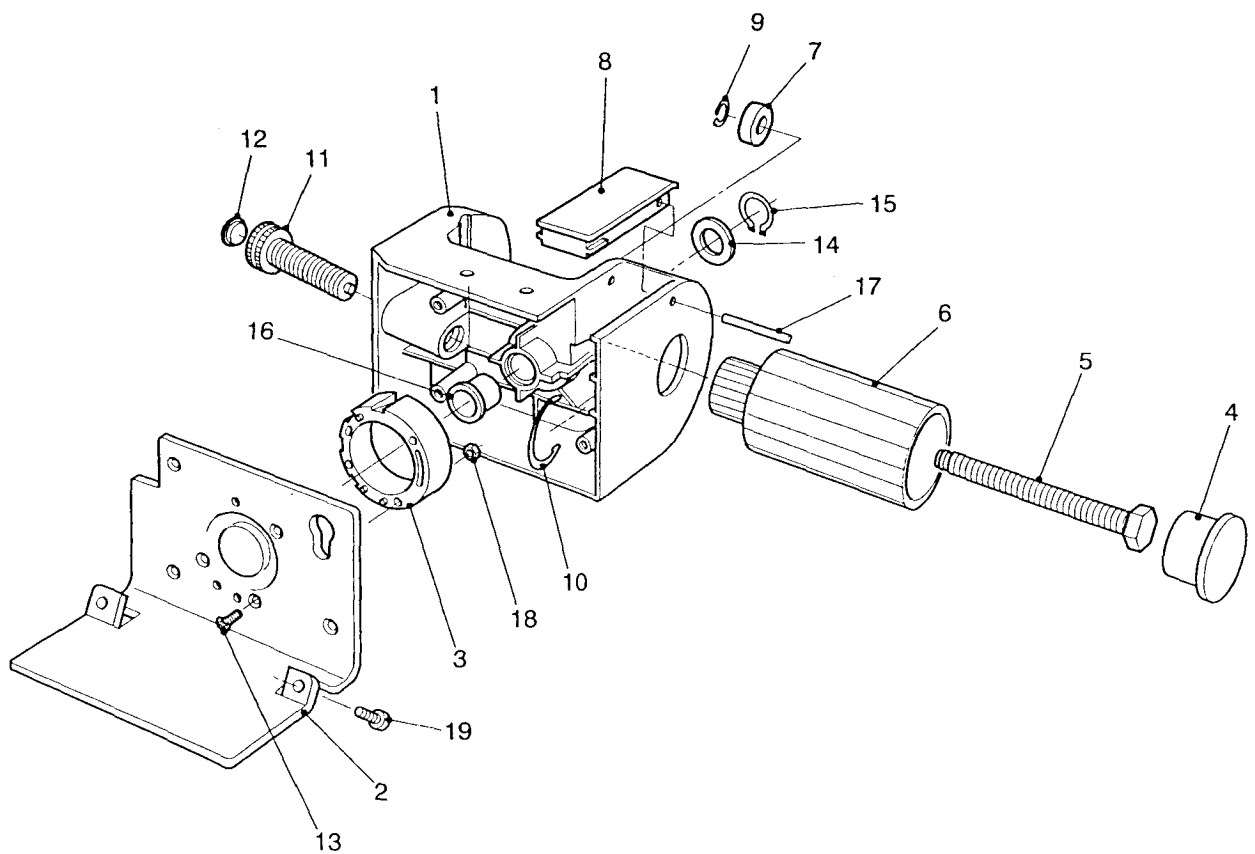


GM0351-A

Figure 7-2 Plunger clamp and half nut assembly IP diagram

Table 7-3 Pole clamp assembly IPL

Item (Fig. 7-3)	Description	Part number	Remarks
—	Pole clamp assembly	0131-0083	Fig. 7-1 and 7-3
1	Clamp body, die cast	0131-0061	—
2	Securing plate	0131-0074	—
3	Locating ring	0127-0064	—
4	End cap	0127-0076	—
5	Clamp bolt	0131-0092	—
6	Handle	0127-0060	—
7	Clamp pad	0131-0093	—
8	Blanking cover	0127-0077	—
9	Circlip RW6	5030-2620	—
10	Crescent circlip	5030-5710	—
11	Special screw	0127-0098	—
12	Nylon plug	5321-3010	—
13	Screw M3 x 10 pozi csk	5000-6317	3 off
14	Disc spring	5014-1170	—
15	External circlip type 7100-010	5030-4010	—
16	Nylon bush	5708-1005	—
17	Spirol pin 3 x 26	5028-3408	—
18	Nut M3 hex full	5011-0550	3 off
19	Screw M4 x 10 slot pan head	5001-0212	2 off



GM0352-A

Figure 7-3 Pole clamp assembly IP diagram

Table 7-4 Motor and leadscrew assembly IPL

Item (Fig. 7-4)	Description	Part number	Remarks
1	Leadscrew	0132-0024	Fig. 7-1 and 7-4
2	Grub screw, occlusion adjusting, M3 x 3 skt. head	5008-2975	—
3	Occlusion adjusting nut	0132-0057	—
4	Spring, occlusion sensing	5752-0077	—
5	Ball race plus 2 washers	5708-1020	In kit form
6	Bearing PEM-PAB-312	5708-1010	—
7	Leadscrew coupling, nylon	0127-0074	Anti-clock thread
8	Motor/gearbox assembly	0138-0026	Fig. 7-1 and 7-4

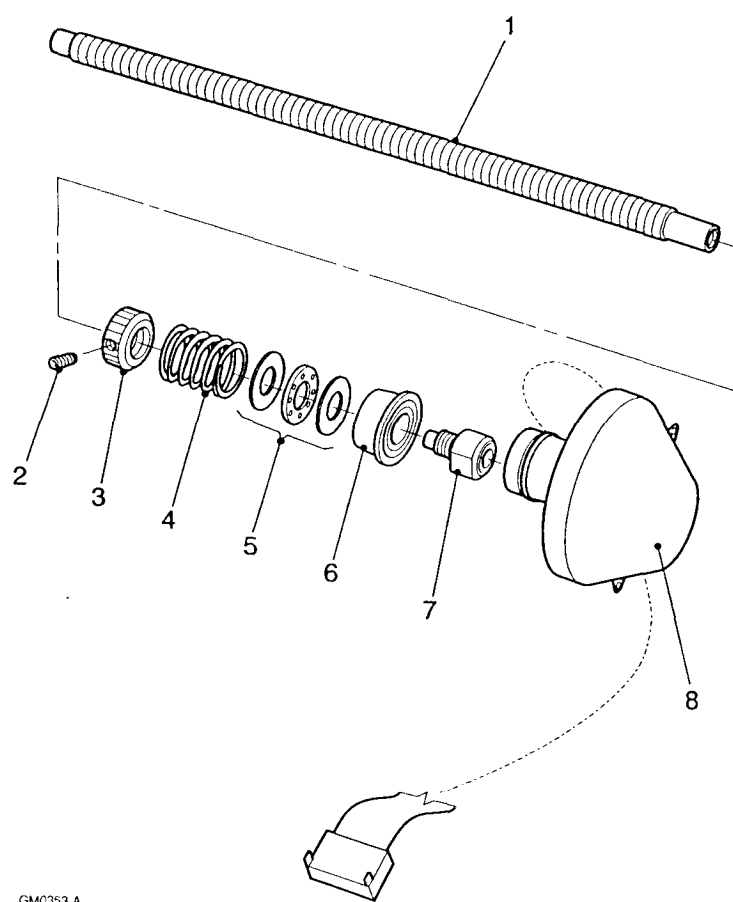


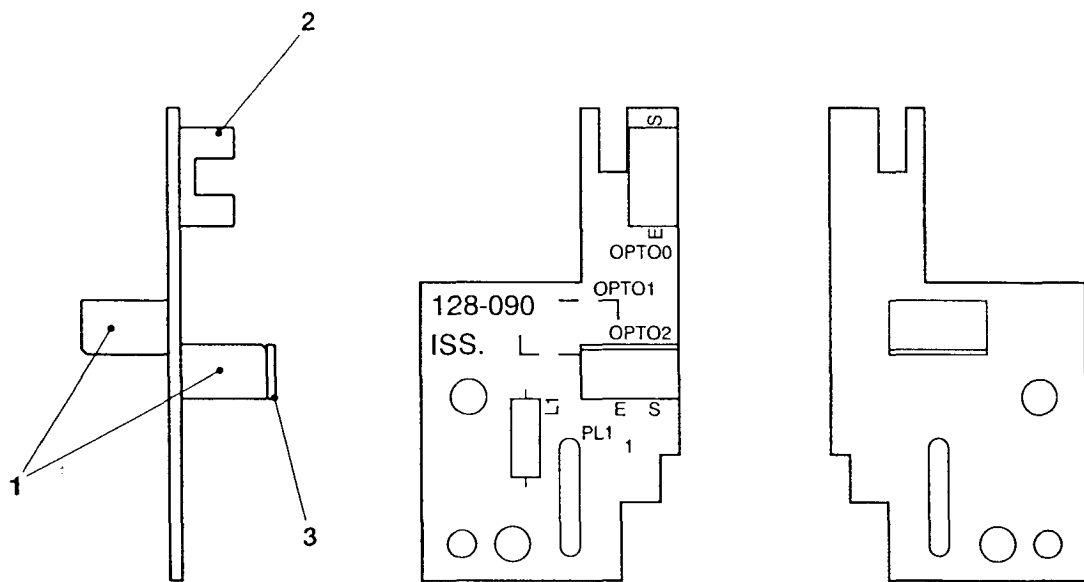
Figure 7-4 Motor and leadscrew assembly IP diagram

Table 7-5 Opto sensors board assembly IPL

Item (Fig. 7-5)	Description	Part number	Remarks
—	Opto sensors board assembly	0128-0090	Fig. 7-1 and 7-5
1	Opto interrupter HOA 0875-051	2430-1200	OPTO 1 and OPTO 2
2	Opto interrupter HOA 1882-012	2430-1202	OPTO 0
3	Sensors flag constraint	0127-0075	—

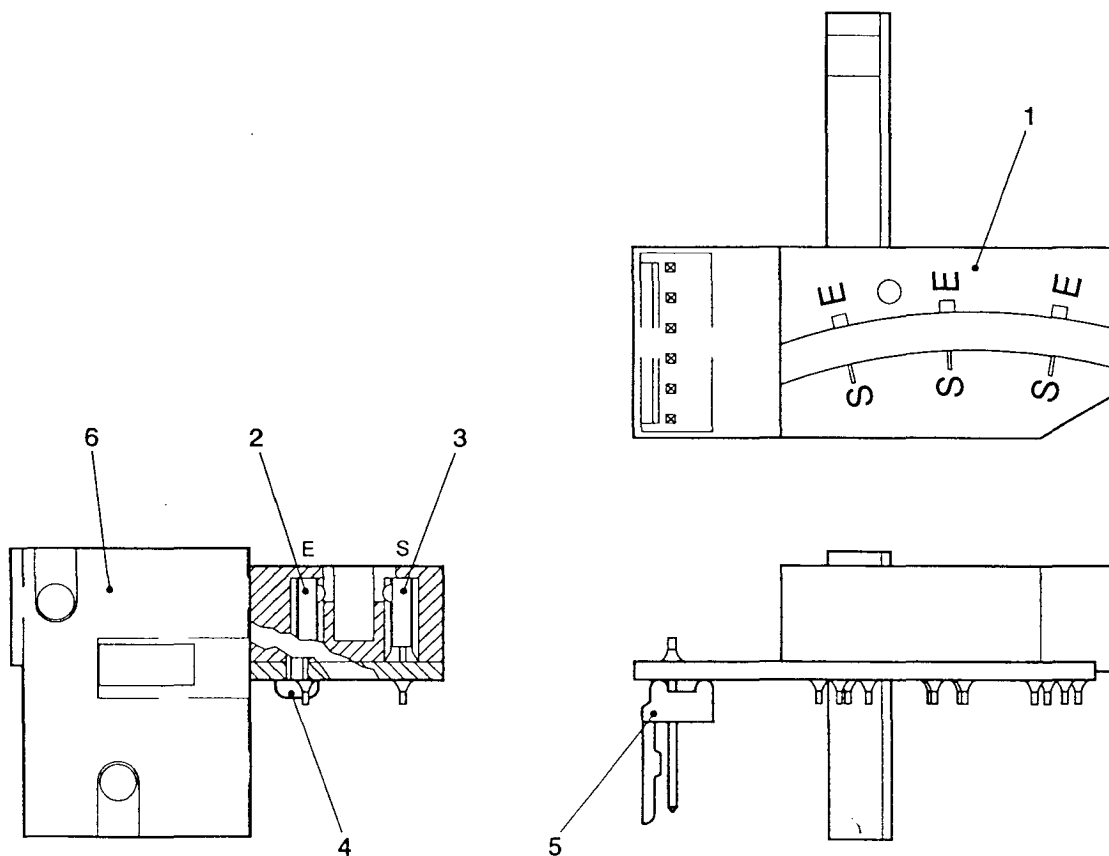
Table 7-6 Size sensors board assembly IPL

Item (Fig. 7-6)	Description	Part number	Remarks
—	Size sensors board assembly	0130-0017	Fig. 7-1 and 7-6
1	Size sensor moulding	0130-0024	—
2	D1, D2 and D3 LED IR SEP8506-3 Honeywell	2424-1010	3 off
3	Q1, Q2 and Q3 Tran photo SDP8406-3 Honeywell	2425-3020	3 off
4	Screw PSM	5017-9908	—
5	Header 6 way 6410	3750-7471	—
6	Size sensor shim	0130-0100	0.6; 0.8 or 1 mm thick



GM0354-A

Figure 7-5 Opto sensors board assembly IP diagram



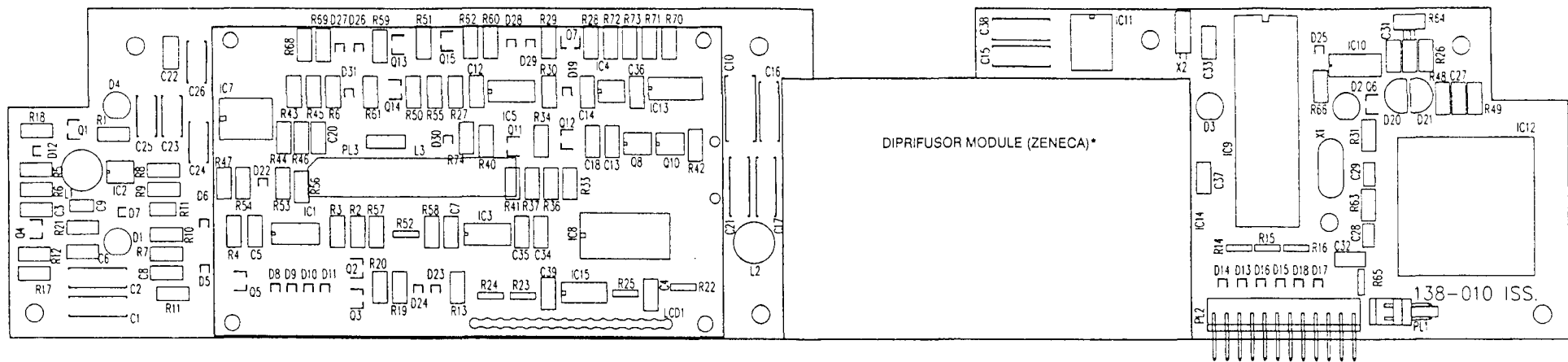
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Figure 7-6 Size sensors board assembly IP diagram

Table 7-7 Main board assembly IPL

Item/ident. (Fig. 7-7)	Description	Part number	Remarks
—	Main board (plus TCI module)	0138-0010	Fig. 7-1 and 7-7
—	Main board (no TCI module)	0138-0028	—
1	IC skt, 32 pin	3770-2200	Under item 6
2	Pillars for sounder	5034-0200	4 off
3	Screw, M3 x 16, slot, pan head	5000-6550	2 off
4	Nut, M3 hex full, nylon	5011-0520	4 off
5	Spacer, nylon	2422-9871	4 off
6	Program EPROM	0138-0015	—
7	Sounder	3430-1205	—
9	Housing, 2 way	3750-2060	—
10	Screw, M2 5 x 12 slot, pan head, nylon	5000-5050	4 off
11	Nut M 2.5, full, nylon	5011-0420	4 off
12	Terminal strip	3775-2010	—
13	Socket, strip	3775-2011	—
14	Self-adhesive pad	055-351	1 off; under crystal
15	Insulator sheet	0138-0023	TCI only
16	Sleeve, H10 x 10, black, helsyn	5316-2430	TCI only, 2 off
17	Aerial for TCI module	0138-0025	TCI only

(contd.)



*NOTE:
Main Board with DIPRIFUSOR Module (as drawn) part no. 0138-0010
Main Board without DIPRIFUSOR Module part no. 0138-0028

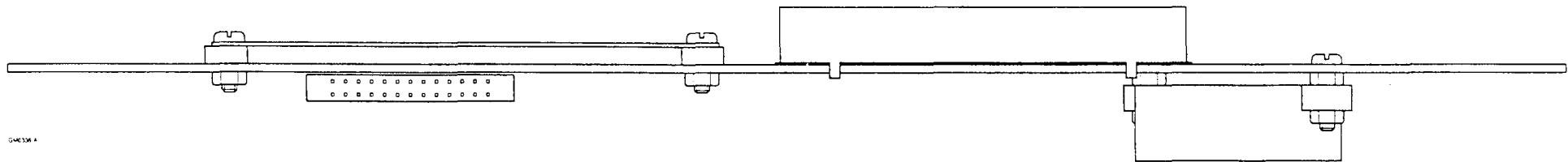


Figure 7-7 Main board assembly IP diagram

Table 7-7 Main board assembly IPL (contd.)

Item/ident. (Fig. 7-7)	Description	Part number	Remarks
C1, C2, C15 to C17, C21 and C38	Capacitor, 10 μ F 16 V S/M	2213-0123	7 off
C3 to C8, C11 to C14, C18, C20, C22, C27, C31 to C37 and C39	Capacitor, 47nF S/M	2251-1720	22 off
C9, C28 and C29	Capacitor, 22 pF S/M	2250-3450	3 off
C10	Capacitor, 100 μ F 10 V	2201-0150	—
C23 to C26	Capacitor, 1 μ F 63 V S/M	2212-7660	4 off
D1 and D2	LED yellow 3 mm	2422-2217	2 off
D3	LED green 3 mm	2422-3217	—
D4	LED red 3 mm	2422-0350	—
D5, D6, D12, D19, D26 to D29	Diode rectifier	2402-3460	8 off
D7	Diode rectifier	2402-2860	—
D8 to D11, D25	Diode rectifier	2402-2023	5 off
D13 to D18, D22 to D24, D30 and D31	Diode Zener	2406-3730	11 off
D20	Diode Zener	2406-0350	—
D21	Diode Zener	2406-0450	—
IC01	IC MC74HC164D Motorola	2662-5227	—
IC02	Regulator MAX4391CSA S/M Maxim	2800-1825	—
IC03	IC S/M 74HC00D	2652-5027	—
IC04	IC S/M MAX603CSA Maxim	2800-1880	—
IC05	IC MC14093BD Motorola	2652-1427	—
IC07	IC MAX232CWE Maxim	2702-0036	—
IC08	IC HM62256LF10 Hitachi	2706-0255	—
IC09	EPROM AT29C040 Atmel	2706-2250	—

(contd.)

Table 7-7 Main board assembly IPL (contd.)

Item/ident. (Fig. 7-7)	Description	Part number	Remarks
IC10	IC MAX691ACSE Maxim	2702-1258	—
IC11	IC DS Dallas 1202 S	2702-1236	—
IC12	IC MC68HC11K1CFN4 Motorola	2712-0259	—
IC13	IC 74HC157	2670-5650	—
IC14	TCl module	0138-0024	—
IC15	IC 74HC14	2652-6850	—
L01	Inductor, 220 μ H	3320-8010	—
L02	Inductor, 1 mH	3321- 0010	—
L03	Inductor, bead	3335-1000	—
LCD1	LCD Module	2432-7010	—
PL01	Header 2 way	3750-7083	—
PL02	Header 12 way	3750-8080	—
PL03	Header 26 way, dual row	3750-6520	—
Q01 to Q07, Q11, and Q13 to Q15	Transistor	2450-2906	11 off
Q08 and Q10	Transistor	2462-1760	2 off
Q12	Transistor	2455-2750	
R01 to R04, R27, R29, R30, R45, R46, R50, R55 to R60, R64, R66, R69 and R74	Resistor, 10K, 5%, 1/4 W	2013-0060	20 off
R05, R33, R34, R43 R44, R47, R53 and R54	Resistor, 1K, 5%, 1/4 W	2012-7560	8 off
R07, R08 and R51	Resistor, 47K, 5%, 1/4 W	2013-1660	3 off
R09 and R10	Resistor, 150K, 5%, 1/4W	2013- 2960	2 off

(contd.)

Table 7-7 Main board assembly IPL (contd.)

Item/ident. (Fig. 7-7)	Description	Part number	Remarks
R11	Resistor 6R8, 5%, 1/4 W	2012-2060	—
R12	Resistor 910R, 5%, 1/4 W	2012-7360	—
R13, R40 to R42, R67 and R68	Resistor 100R, 5%, 1/4 W	2012-5060	6 off
R14, R15, R16 and R65	Resistor 10K	2081-0031	4 off
R17, R36 and R37	Resistor 4K7, 5%, 1/4 W	2012-9160	3 off
R18 to R21	Resistor 470R, 5%, 1/4 W	2012-6660	4 off
R22 to R25, and R52	Resistor 100R	2080-5031	5 off
R26, R28, R31, R70, and R71 to R73	Resistor 100K, 1%, 1/4 W	2013-2560	7 off
R48 and R49	Resistor 11K, 1%, 1/4 W	2013-0163	2 off
R61 and R62	Resistor 47R, 5%, 1/4 W	2012-4160	2 off
R63	Resistor 10M, 5%, 1/4 W	2013-7560	—
X1	Crystal 16 MHz	3352-0227	—
X2	Crystal 32.768 kHz	3352-0440	—
RTI	Thermistor NTC 100K	2075-8220	—

Table 7-8 Regulator board assembly IPL

Item/ident. (Fig. 7-8)	Description	Part number	Remarks
—	Regulator board assembly	0130-0013	Fig. 7-1 and 7-8
1	Shield for fuse	0130-0036	—
2	RF screen assembly	0130-0016	—
3	Heatsink	2495-0040	—
4	Fuse holder	3412-0227	3 off
5	Fuse cover	3142-0228	—
C01	Capacitor 22 pF, 2%, 100 V	2250-3449	—
C02	Capacitor 47 pF, 2%, 100 V	2250-4249	—
C03 and C04	Capacitor 220 pF	2250-5910	2 off
C06	Capacitor 2 μ F 63 V	2200-8002	—
C07	Capacitor 1000 μ F 10 V	2204-7412	—
C08 and C09	Capacitor 1 nF 10% 100 V	2250-7612	2 off
C10	Capacitor 47 μ F 400 V	2204-5810	—
C11	Capacitor 10 nF 63 V	2251-0142	—
C12	Capacitor 10 nF 10% 100 V	2220-7645	—
C13	Capacitor 1 μ F	2213-7630	—
C14	Capacitor 100 nF 250 V	2221- 0150	—
D01 and D05	Diode	2402-4010	2 off
D02	Diode, Zener, 13 V, 5%, 1.3W	2406-5706	—
D03	Diode, 7.5 A, 45 V	2402-2420	—
D04	IC Volt regulator	2800-0020	—
D06	Diode Zener 13 V 5% 5 W	2406-5710	—
D07	Bridge rectifier 1.5 A, 600 V	2400-3410	—
D09	Diode Zener 6.2 V 5%	2406-3704	—

(contd.)

Table 7-8 Regulator board assembly IPL (contd.)

Item/ident. (Fig. 7-8)	Description	Part number	Remarks
FS1	Fuse 1A	3410-3705	—
FS2	Fuse 500 mA.	3410-3003	—
FS3	Fuse 2A	3410-4505	—
IC1	IC Volt regulator	2800-0040	—
IC2	Opto coupler	2430-0010	—
L2	Inductor 2 x 47 mH	3321-4110	—
PL11	Header 4 way	3750-7270	—
PL12	Header 2 way	3750-7070	—
Q1	Transistor, thyristor, 5A, 200V	2400-2010	—
Q2	Transistor, NPN	2450-2718	—
Q3	Transistor, Mosfet, 2.6A 800V	2462-9710	—
R01 to R04, and R11	Resistor, 220R, 5%, 1/8 W	2012-5800	5 off
R05	Resistor, 27R, 5%, 1/8 W	2012-3500	—
R06 and R07	Resistor, 10K, 5%, 1/8 W	2013-0000	2 off
R08	Resistor, 1K2, 5%, 1/8 W	2012-7700	—
R09	Resistor, 3K6, 1%, 1/8 W	2012-8830	—
R10	Resistor, 2K2, 1%, 1/8 W	2012-8330	—
R13	Resistor, 390K, 5%, 1/8 W	2013-3900	—
R14	Resistor, 330K, 5%, 1/8W	2013-3700	—
R15, R19 and R25	Resistor, 4K7, 5%, 1/8W	2012-9100	3 off
R16	Resistor, 470R, 5%, 1/8W	2012-6600	—

(contd.)

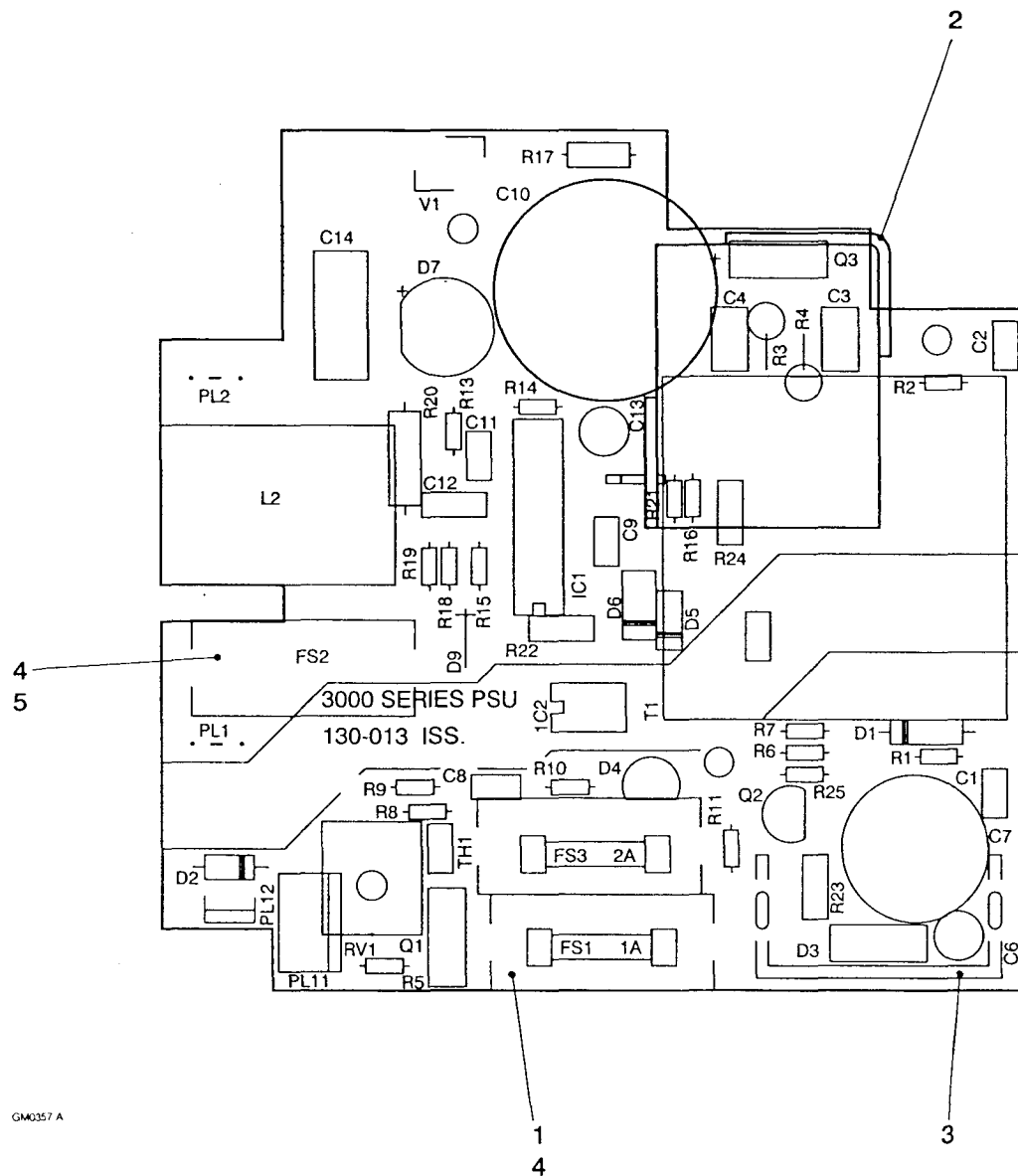


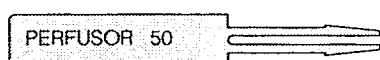
Figure 7-8 Regulator board assembly IP diagram

Table 7-8 Regulator board assembly IPL (contd.)

Item/ident. (Fig. 7-8)	Description	Part number	Remarks
R17	Resistor, 1R8, 5%, 1/4 W	2012-0603	—
R18	Resistor, 47K, 5%, 1/4 W	2013-1600	—
R20	Resistor, 1M, 5%, 1/4 W	2013-5003	—
R21	Resistor, 10R, 5%, 1/8 W	2012-2500	—
R22	Resistor, 10R, 5%, 1/4 W	2012-2503	—
R23	Resistor, 220R, 5%	2012-5803	—
R24	Resistor, 1K, 5%, 1/4 W	2012-7503	—
R25	Resistor, 4K7, 5%, 1/8 W	2012-9100	—
RV1	Potentiometer, 470R	2088-2002	—
T1	Transformer	0130-0021	—
TH1	Thermistor, NTC	2075-5210	—
V1	Thermistor, I-limiter	2075-0410	—

Table 7-9 Braun Perfusor 50 ml syringe conversion kit: IPL

Item/ident. (Fig. 7-9)	Description	Part number	Remarks
—	Perfusor conversion kit (for non TCI pumps only)	0131-0048	See Chap.8 for conversion procedures
1	Perfusor spacer tube	0131-0051	—
* 2	Nearly empty flag for Perfusor	0131-0121	New style, barb fitted
2	Nearly empty flag for Perfusor	0131-0041	Old style, screw fitted
3	Screw M 2.5 x 5 slot pan head	5000-4642	Used for old style flag
4	Plunger clamp plate	0131-0073	—
5	'P' Label	0131-0065	—



* New style. Barb fitted. Half nuts F and onwards.



Old style. Screw fitted. Half nuts E and previous.

GM0580-A

WARNING
Do not attempt to convert a MCI + TCI pump in order to use a Braun Perfusor syringe

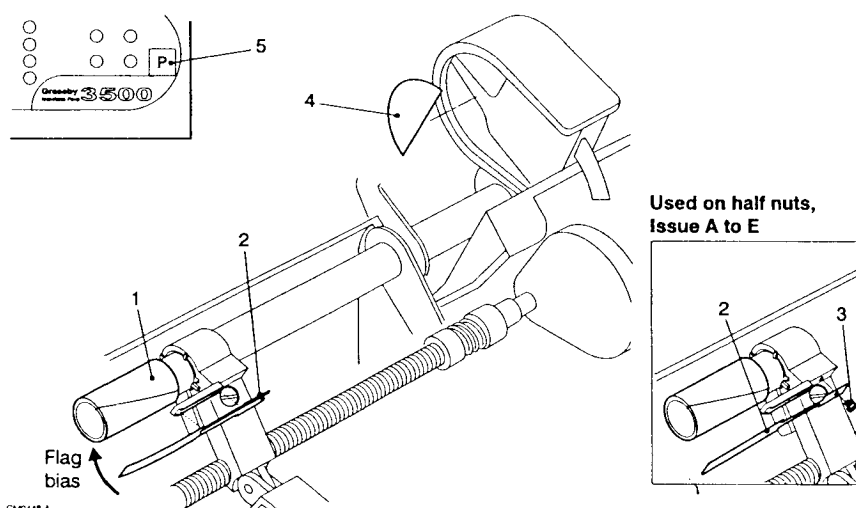


Figure 7-9 Braun Perfusor 50 ml syringe conversion kit: IP diagram

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CHAPTER 8

BRAUN PERFUSOR CONVERSION

Syringe conversion procedures (non-TCI only)

Introduction

The 3500 can easily be converted, if required, in order to use the 'Braun Perfusor 50 ml syringe'. The Perfusor conversion kit part number is 0131-0048 (see page 7-23).

The conversion procedures are detailed below and are shown in Figure 8-1.

WARNING

The MCI plus TCI version of the pump cannot be converted to use the Braun Perfusor syringe.

Do not attempt to convert a MCI plus TCI pump to use a Braun Perfusor syringe.

Nearly empty flag conversion

Open the pump case (page 2-7) and temporarily displace the Distribution board assembly (Fig. 7-1) by unscrewing the screw at the bottom of the assembly.

Remove the *standard flag* from the top of the half nut (retain the *standard flag* for possible future use). Fit the elongated Perfusor 50 ml *nearly empty flag* (see page 7-23) by inserting it into the grooves on the half nut (see Fig. 8-1), and ensuring that the flag is fitted so that the small amount of flag bias is in the direction of the arrow shown in Figure 8-1.

Note:

If not already biased, bend/bias the end of the flag in the direction of the arrow shown in figure 8-1 a distance of approximately 2 mm, this will ensure that the flag (when it moves fully to the left) does not touch the left hand post.

Spacer tube fitment

Carefully lift up the left hand end of the inner metal tube and fit the nylon *spacer tube* (part number 0131-0051) over the tube. The *spacer tube* acts as an end of travel stop when the half nut assembly is moved to the left.

Plunger clamp fitment plate

Fit the self adhesive half-round *plunger clamp plate* (part number 0131-0073) to the left hand side of the plunger clamp. It must be fitted to the vertical face of the plunger clamp so that it covers both quadrant vanes (Fig. 8-1).

(contd.)

Braun Perfusor conversion

Reassembling case

Reassemble the case as detailed on page 2-7.

Braun perfusor selection

The Braun Perfusor 50 ml syringe is selected for use (on the pump) by using a special configuration command.

First select the *configuration mode* (see page 2-1) and then select and display the syringe brand screen.

Simultaneously press the following three buttons:

ALARM, BOLUS and OFF.

The 3500 will then switch to the Braun Perfusor syringe mode and other syringe brands will automatically be disabled. The 3500 syringe display will show:

BRAUN PERFUSOR 50 ml

and the **CHANGE** button, whilst in this mode will become ineffective.

'P' label fitment

Fit the self adhesive 'P' label (part number 0131-0065) to the front of the 3500 in the area just above and to the right of the product name (Fig. 8-1). This label acts as a visual reminder that the pump must only be used with the Braun Perfusor syringe.

Reselecting 'various' syringe brands

To reselect the various syringe brands carry out the following mechanical and programming procedures:

Mechanical procedures

1. Take the case apart (page 2-7).
 2. Replace the original standard nearly empty flag.
 3. Remove the nylon spacer from the left hand side of the inner metal tube.
 4. Remove the adhesive plunger clamp plate.
 5. Reassemble the case.
 6. Remove the adhesive 'P' label from the front of the pump.
- (contd.)

Programming procedures

7. With the pump switched **ON** and

BRAUN PERFUSOR 50 ml

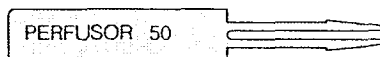
displayed within the configuration mode (page 2-1), simultaneously press the following three buttons:

ALARM, BOLUS and OFF

in order to set the configuration mode so that the various brands of syringe may be selected.

8. Set the pump to the brand of syringe that is going to be used and then press the **STOP** button in preparation for the next infusion.

Nearly empty flag for Perfusor



New style. Barb fitted. Half nuts F and onwards.



Old style. Screw fitted. Half nuts E and previous.

GM0447-A

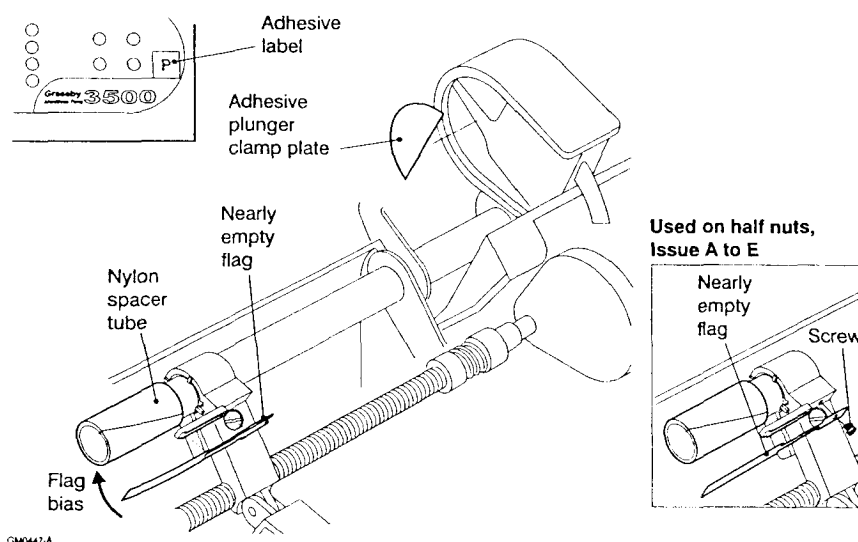


Figure 8-1 Braun Perfusor conversion: parts required

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MISSION STATEMENT AND CORPORATE IDENTITY

MISSION STATEMENT

Graseby Medical provides innovative products and services for drug delivery by infusion and for neonatal apnoea monitoring.

Our aim is to exceed our customers' expectations for quality, performance and value.

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